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Editor Frederick Hawkins 432-5913

## LEHIGH 99'ER COMPUTER GROUP

Next meeting: Monday, June 17  
7:30 PM as usual, we hope.

Community Room, First Nat'l Bank  
7th and Hamilton, Allentown

# THE I/O PORT

Yes, we have no BASIC this month.

Your worst fears have been realized: your slightly frazzled editor is somewhere in the bit stream.... Or have they?

The I/O PORT is presenting a two-up hardware special issue. The first is from that hotbed of TI activity, the Northwest Ohio 99'ers (aka OH-MI-TI and New Horizons). In their Jan newsletter, John Clulow and Ron Gries add 8K to the EdAsm cartridge. The other is from the TI Users of Perth, Western Australia, whose members Bernie Elsner and Phil West are on the cutting edge of TI hacking, TI writing and my all-time list of best articles anywhere, anytime. They add three chips to the console, creating the first-ever internal 32K expansion.

Between the two lurk the following possibilities:

for a bare console owner: A 32K expansion without a p-box.  
(price range: \$27 to \$40)

for a hardware hacker: A battery-powered RAM cartridge.  
Or a battery-powered 32K expansion memory.

Better prices for the 6264-LP15

The Hitachi static ram chip used in both articles may be gotten much cheaper than the reprints imply. Computer Shopper, for instance, has three ads in their May issue that range from \$12.90 to \$10.50. (I recall a fourth for a guaranteed but used chip at \$8.30, but can't find it).

DRAMEN 1-800-438-7925	HM6264LP-15	\$12.90
MICROPROCESSORS UNLIMITED	6264LP-15	\$10.50
24,000 S. PERORIA AVE.		
BEGGS, OK 74421	1-918-267-4961	
I. C. EXPRESS	6264LP-15	\$11.50
15358 VALLEY BOULEVARD		
CITY OF INDUSTRY, CA 91746	1-818-369-2669	
	1-800-892-8889 orders \$10 min	

Replacement PROM extenders available from TI

For about \$5, you can get the right-angle cartridge connector. I believe the TI source is in Lubbock, but check first.

The I/O Port, founded on the Reefs of Dismay, is limping towards the Keys, under half-power and nearly rudderless. Dis May wasn't, note our new issue number and dis June marks our first attempt to mail everyone their issue by (or nearly) the first of each month.

### An unsolicited rave

Those of us blessed with a disk drive or two, but without the new double-density cards, are often blessed with about a hundred disks. Unlike the tape user with stacks of (is it empty or full) little boxes, the disk user can't read/write the diskname on the edge of the disk sleeve. Thus, simple stacks are a no-no, leading us to such innovations as the plastic shoebox. These devices let us put 25 or so disks inside with four or five dividers that you flip back and forth to find, sort and keep track of...

One problem is that they don't expand, so as you get to and exceed the advertised limits, disks get harder to find and easier to mash. Plus if you use the machine much at all, how do classify an XBASIC FORTH system, when you've only five categories and FORTH was squeezed in with the EdAsm disks?

Enter the DISKBANK, THE SYSTEM.

This nifty disk box links together with its brothers, giving each set of 10 disks their own trapdoor, labelspace and portability. The great thing about them is when you pull a disk to use it you can leave the door open.... Then when you're done using the disk the open door shows you where to look for the sleeve. Real practiced types (the second time), you'll find that you leave the sleeve in front. That way you can read what's in the drive without opening it. Yeah, I know you can put the sleeve in front of the shoebox, but then you've got to figure out where it's supposed to go all over again.

If DISKBANK has a flaw, it just isn't cheap enough. Five of them will cost you about \$22 (at Service Merchandise, locally). But, I've seen them for about \$3 at computer fleamarkets.

>Frederick Hawkins

**SUPER-MODULE !**

## Adding 8K to Your E/A Module

by Ron Gries and John Clulow  
New HorizonsQuestions about this project may  
be directed to Ron Gries:

(419) 874-1414

The project described here adds 8K of RAM memory to the Editor/Assembler Module. At the present time, a circuit for battery backup is not available. We hope to present one sometime in the near future (when Ron gets time to do it.) But you should find the 8K addition useful even without battery backup and especially so if you do much assembly language programming.

As usual, neither Ron and I nor the New Horizons users group can assume any responsibility for any loss or damage arising from the information presented here. We also do not assume responsibility for its accuracy or completeness. If you decide to attempt this project, you do so entirely AT YOUR OWN RISK.

The memory used is the Hitachi CMOS HM6264P-15 (\$34.95). If you want the capacity for battery backup later on, you'll need the more expensive LP-15 version (\$39.95). Prices on both devices will probably drop in the next few months. One source of the RAM chip is JDR Microdevices, 1224 S. Bascom Ave., San Jose, CA 95128 Ph: (800) 538-5000.

Another required item is TI game module which is foiled on both sides. To determine this, push back the sliding door and see if there is metal showing on both sides of the edge card. Several games have such a board; we happened to use a Munch Man module which was purchased for \$.99.

You'll also need an Editor Assembler module, of course. Because the project involves transplanting the E/A GROM chip, it does involve some risk of destroying the E/A module! It would be a good idea NOT TO TRY IT WITH AN E/A MODULE YOU CAN'T AFFORD TO LOOSE.

The only other parts you'll need are a 1K resistor (e.g., Radio Shack 271-023) and some insulated wire -- preferably wire wrap (e.g., 278-501). You'll also need a vacuum-type solder remover, rosin core solder, and a soldering pencil.

We strongly recommend that if you have had no prior experience handling CMOS devices, desoldering components from printed circuit boards, etc. you should ASK SOMEONE WHO HAS TO HELP YOU.

First un-screw the shell of the game module and open it by pulling the case apart at the ends of the slotted side. Remove the PC board while holding the sliding door down. Note the position of the spring device and the grooves it fits into in the sliding door. Note that the spring is on the UNDER-SIDE of the PC board.

Un-solder and remove the GROM and ROM chips. They should be located as shown in FIG. 3. The ROM chip is the larger of the two. To remove them heat each solder connection on the underside of the board and use the vacuum device to remove most of the solder. Then gently pry up on one end of the device while heating pins on the underside of the board at the same time.

A capacitor should be located next to pins 21-24 of the ROM. Desolder the ground end from its soldering pad, leaving the +5V end (nearest the back of the board) attached. With a knife, carefully break the foil between the two adjacent soldering pads where the capacitor was connected -- See Fig. 2. Then re-solder the ground end of the capacitor to the pad on the right. Finally, solder one end of a short piece of wire to the pad on the left (where the capacitor used to be) and the other end to hole 18 of the removed ROM (See Fig. 1 for ROM pin numbering). This will be the seventh hole from the back of the board on the side closest to the capacitor.

When a command module is inserted, it normally resets the computer. If you want to disable this auto-reset in the new E/A module, remove the resistor at the opposite end of the board (See FIG. 3).

Figure 1 gives a pin diagram of the HM6264 RAM with a typical 4K ROM superimposed. You will note that the actual width of the two chips is identical but the RAM is longer. The ROM is drawn narrower simply for clarity in showing corresponding pin numbers. In the following, all pin numbers will be preceded with "ROM" or "RAM" to indicate which numbers are involved.

In handling the CMOS RAM chip take precautions to minimize static electricity. Don't work on carpet, touch a ground before handling the device, handle it by the plastic body, and touch the pins as little as necessary. When soldering, hold the pencil on the pins for the least time required to make the connection -- try not to use more than 1 to 2 seconds. Remove the RAM from its anti-static tube. Figure 1 is a top view. Place the device on its side on a table or other flat, hard surface and move the body of the device to bend the pins closer to a right angle with respect to the body. Do this for both rows of pins, and check to make sure that the pins roughly line up with the holes in the game PC board. Orient the chip as in Figure 1 and bend RAM pins 1 2 20 27 and 28 straight out. Now insert the RAM into the game PC board such that the notched end is flush with the back of the board RAM pin 3 should go into ROM hole 1, RAM pin 26 into ROM hole 24 etc.

With the RAM in place, solder in one pin on each side to hold it. Connect a wire from RAM pin 27 (bent up) to the Write Enable pin on the edge connector. This is the third one from the left looking at the top of the board (see FIG. 3) and it is not connected by foil to the PC board. Connect a wire from RAM pin 2 (bent up) to Address line 12 on the edge connector (7th pin from the left). This edge pin also doesn't have a foil connection to the board.

Solder a short wire from RAM pin 20 (bent up) to RAM pin 22. It will be relatively easy to solder one end of the wire to RAM pin 20 but RAM pin 22 is in a hole and a little more difficult to get at. Solder the wire as close to the board as possible using as little solder as possible. Solder one lead of the 1K resistor in the soldering pad just below the left side of the GROM holes. This pad is in a foil path leading from the gnd end of the capacitor to the right-most edge card pin. The resistor lead can be pushed through the hole. Solder the other end of the resistor lead to RAM pin 20 (bent up).

Solder a short wire from the +5 end of the capacitor lead (nearest the back of the board) to RAM pin 28 (bent up).

Now all that remains is to install the E/A GROM. Open the E/A module and remove the PC board. Unsolder and remove the GROM using the same procedure as

above. Place the E/A GROM on the new board in the holes left by the old GROM with the notched end of the GROM toward the back of the board.

Finally, solder all IC pins in their respective pads for both the RAM and GROM. Place the spring in the BOTTOM of the E/A module case, locate the sliding door properly, put the new PC board in place, and snap the case closed. Then replace the screw.

The first thing to do is make sure your E/A GROM still works OK. Then you can test out your RAM with the following program.

```

100 INPUT "NUMBER 0-255? ":X
110 CALL LOAD(24576,X)
120 CALL PEEK(24576,X)
130 PRINT "MEMORY HAS ";X
140 PRINT
150 GOTO 100
    
```

When you enter a number from 0 to 255, you should see the same number displayed on the screen having been stored by 110 and read by line 120. If the number the computer returns is different from the one you entered, the device is not working properly. Remove it and retrace all steps above until you find the problem. The address 24576 is >6000. Your new RAM goes from >6000 to >7FFF or in decimal from 24576 to 32767. You may want to check out several addresses in this range to make sure they are working properly.

There are a number of things you can use the new RAM for. In assembly language programs you can use an ADRG >6000 directive to have to loader place your object code in the new RAM. Alternatively, you can change the First Free Address in High Memory (FFAH) to >6000 with a CALL LOAD(8228,96,0) and then load your program with a CALL

LOAD("DSK1.NAME") as usual. If you plan to load other programs, you can change the FFAH back to >A000 by CALL LOAD(8228,160,0).

I have been using the new 8K of RAM to hold the DEBUG program when working on assembly language programs. An article by Jon Bannister of 9T9 users group in Toronto described a modification to the speech synthesizer to activate (ground) the LOAD interrupt line on the 44 pin I/O bus. This causes the computer to do a BLWP to vector >FFFC where >FFFC contains the Work-space Pointer and >FFFE the Program Counter. So at any time in the execution of a program (like when it inevitably locks up) I press a button and branch to the debugger.

Jon's device is pretty easy to make. You need a momentary contact, normally open push button switch (like Radio Shack 275-1547), a .1 mF bypass capacitor (272-135), and a 2.2K resistor (271-1325). Solder the capacitor across the switch keeping the leads as short as possible. Solder one lead of the resistor to one side of the switch and the other lead to a 7" insulated wire. Connect the other end of the wire to the LOAD pin on the Speech Syn. This is pin 13 on the I/O bus. Looking at the edge card at the upper right of the console, pin 13 is the seventh pin from the left on the bottom. Jon recommends that you flip the board upside down so that you cannot see any components, and place the black female connector on the right side. Pin 13 LOAD is then the seventh pin from the bottom.

A second 7 in. insulated wire should be soldered to the other side of the switch and then to Ground - leads 11 12 13 and 14 from the bottom with the black connector on the right. You can

easily recognize them because they are soldered together.

All that remains is to mount the switch inside the speech synthesizer. If you're using the Radio Shack switch, you'll need a 5/16 in. hole.

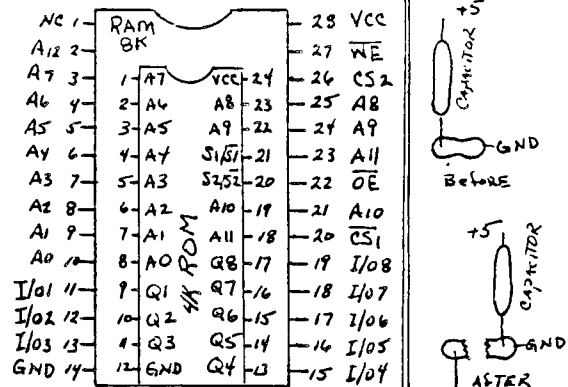
Now, if you've made it this far, put in your E/A module, connect the modified Speech Syn, place the E/A disk with DEBUG or it in drive one and run the following program:

```

100 CALL INIT
110 CALL LOAD(8228,96,0)
120 CALL LOAD("DSK1.DEBUG")
130 CALL LOAD(-4,131,224,112,190)
140 CALL LOAD(8228,160,0)
150 PRINT "PRESS Q THEN ENTER"
160 CALL LINK("DEBUG")
170 END
    
```

This will load the DEBUG utility. Now enter BYE to leave basic and select an option of Editor Assembler - e.g., Load and Run. When you press the LOAD button on your speech syn, you should be in the debugger. To leave the debugger, use FCTN OUT.

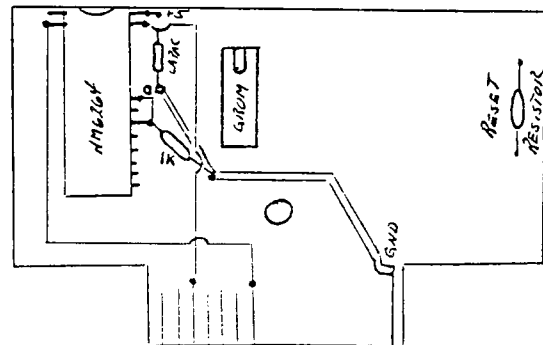
FIG. 1



4M6264P(LP)-15 (LARGER)  
Superimposed ON  
ROM IC (SMALLER)

FIG. 2

FIG 3



from TIUP  
**32K MATCHBOX EXPANSION -**

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june 1985

LEHIGH 99'ER COMPUTER GROUP

## Special Feature

THE TI-99/4 AT  
-----  
( ADVANCED TECHNOLOGY )  
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PART 1.  
-----

32K OF CMOS RAM  
INSIDE THE TI-99/4AT  
( The 'MATCHBOX' expansion! )

By Bernie Elsner and Phil West.  
TI-99/4AT 'AB-USERS' of PERTH.  
WESTERN AUSTRALIA. ( T.I.U.P. )

THE 'ISADUDD' CLUB.  
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Anyone using a computer which has been discontinued by the manufacturer, automatically qualifies for free membership of the rapidly expanding International Society of Amalgamated Dodo Users and Dead Ducks. ( ISADUDD's )

TISADUDD's are luckier than most. Despite the 'DODO' image, there are some real advantages in belonging to this group.

New, and sometimes 'PRE-LOVED' hardware and software are often available at bargain ( DUMPED ) prices.

Initial awe and fear of damaging expensive equipment has disappeared. ( Who's afraid of a \$49.95 computer ? )

Tons of software, books and technical information are readily available.

Contact with many other users has been established.

Creating useful programs is a lot easier than when you first started.

The 'BANK ACCOUNT' has had a chance to recover some lost condition.

At this stage, like us, you may develop an interest in the computer hardware. How it operates, how to fix some of the things that annoy you and how to provide extra features.

SUCCESSFUL MODS.  
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Hardware enhancements that we have added include :-

Installation of a great UTILITY device called 'FINGER PRINT' and the addition of five EXTERNAL dip switches for the TI-(MX 80)-PRINTER. ( For changing Baud Rate and 7-8 Data Bits quickly. )

Beefing up the Expansion Box power supply to permit the use of two internal, CHINNON low power, double sided, slimline, disk drives, PLUS, two optional external drives and WITHOUT ANY FAN in ELSNER'S 'MEGA-CRAZY'

\* \* \*



'supermod' ( Foundation member of 'NOFANS' - The Noise Of Fans is Against Nature Society. )

Installation of a 'GRONOS' load interrupt button. ( The MARK 2 'LA-USERS' version. )

Addition of the 'NEW HORIZON'S USERS GROUP' real time ( battery backed ) clock.

Conversion of a MINI MEMORY to a 'WESTRALIAN INSTRUMENTS' MAXI MEMORY, by replacing the 4K ROM and 4K RAM with an 8K RAM chip. Retaining the MM GROM and battery backup circuit. The ROM data can be restored from cassette with a m-1 routine ( or from disk, using a CORCOMP DD disk controller card. ( To be featured in Part 2. )

Location of 'CONSOLE ROM' in an 8K ( battery backed ) RAM CHIP on the 8 bit data bus. Slowed things down by 25% but has some interesting potential.

Expansion of CPU memory with a 'MATCHBOX' 32K CMOS RAM EXPANSION inside the TI-99/4AT. ( Described in this article. )

These last three mods were made possible by substantial price reductions of a great memory chip, the :-

HITACHI HM6264LP-15

This is a 28 pin - 8K x 8 bit CMOS RAM chip. A Big brother to the 2K x 8 bit HM6116LP-4 used in the MINI MEMORY.

There are several versions of the chip. The one we used is LP ( for Low Power - which is required if you intend to use battery backup ) and 15 ( for 150 nanoseconds ) which is plenty fast enough for ol' TORTOISE-TI....

A year ago, in PERTH, the chip would have cost you \$140.00 and two months ago it varied in price from \$42.00 to \$75.00. It is now available, in sticks of TEN chips from :-

'PRUMARK' ELECTRONICS'

P.O. Box 381,  
CROWS NEST, NSW 2065. or,

P.O. Box 115,  
NUNAWADING, VIC 3131.

For \$256.00 ( \$25.60 per chip. )  
( This includes 20% sales tax and \$4.00 for postage! )

The HM6264 chip is just made for the TI-99/4AT hacker. It is STATIC RAM which does not need the complex refresh circuitry etc. of DYNAMIC RAM and the size is just right for the 8K blocks of CPU RAM.

ON THE DRAWING BOARDS.  
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We are developing several other enhancements for the TI-99/4 AT. All components will be mounted on a board INSIDE the computer. ( An additional external power supply will be required later. )

The projects will include :-

Extensive CRU decoding to allow for new facilities.

Provision of a CRU selectable 8K CMOS RAM chip in the DSR area of CPU RAM from >4000->5FFF.

Console ROM to be hardware switchable between ROM and battery backed CMOS RAM.

( We just might end up with an 80K computer, or better! )

Installation of an EPROM copier-programmer in the computer. Two Zero Insertion Force sockets to be mounted above the ventilation slots at the rear, right hand side of the console. ( That'll really COOK em! )

Provision of a GROM and ROM selector for access to external module cards.

Some of the mods will require M/L routines and we will list those when appropriate.

VAPOUR WARE.  
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Other improvements to be investigated ( straight from the DREAM TIME ) include :-

A RAM DISK, large enough to load a full, double sided, double density disk ( 1440 sectors or 26840 bytes. ) Hmm...that's 45 HM6264 chips which would cost \$1197.00! Well maybe next year. Just think, they might even come down to \$4.95 ea. That would be about \$60 for a SS-DD RAM DISK or \$250 for a DS-DD RAM DISK.

( cont. over page )

32K Matchbox Expansion ( cont. )

Relocation of the 32K CMOS RAM expansion on the 16 bit data bus to eliminate the 16 to 8 bit bus conversion for operations in CPU RAM. ( Too fast for existing software ??? )

Replacing the VDP processor with a TMS 9228 and building VDP RAM up to 256K. WOW! An 80 column MULTICOLOUR text mode. A bit map mode where every pixel can be any one of 16 colours from a palette of 512 colours. Sixteen sprites in any row....

Replacing the TMS9900 with a TMS9995 running at 12 MHz. ( We've done a ROM & RAM 'BRAIN' exchange, why not a 'HEART' transplant too ??? )

This would be tough. The experts say it's IMPOSSIBLE but having acquired a TMS 9995 processor in some recent 'horse trading' we might just be crazy enough to try. After all, the experts didn't tell us we could put 32K of CPU RAM into the console.....

If we ever get this far, Phil will have re-written just about all the TI software and we will change the name of the computer to the 'WESTRALIAN INSTRUMENTS'.

'TURBO TI-99/4 AT+'

IMPORTANT DISCLAIMER.

These articles are written by 'AMATEUR COMPUTER HOBBYISTS'. ( Amateurs by our definition are happy souls who learn less and less, about more and more, as distinct from experts, who rarely smile and learn more and more about less and less. )

We cannot guarantee that any modifications or enhancements described will work on YOUR computer.

We develop our projects on old equipment and accept the risk that it may be damaged. If you have never taken your computer apart, handled CMOS chips or used a soldering iron you should NOT attempt any of the projects described ( unless you can obtain assistance from someone who has. )

By modifying your equipment you will void any manufacturers' warranties still in force.

\*\*\*\*\* WARNING \*\*\*\*\*  
 \* IF YOU ATTEMPT ANY OF THE \*  
 \* MODIFICATIONS DESCRIBED IN \*  
 \* THIS SERIES OF ARTICLES YOU \*  
 \* DO SO AT YOUR OWN RISK \*\*\*\*\*  
 \* \* \* \* \*

32K MATCHBOX EXPANSION.

Our 32K matchbox expansion works fine with the major software packages. ( This article is being written with TI-WRITER using the prototype. )

EXTENDED BASIC. TI-WRITER. TI-MULTIFLAN. TI-LOGO 1 & 2. TI-FORTH. EDITOR ASSEMBLER and

the RS232. F.DISC. TI-DISK CONT., CORCOMP DD DISK CONT. cards, have all been used without any 'APPARENT' problems. However, we pause for another important message :-

\*\*\*\*\* SOFTWARE WARNING \*\*\*\*\*  
 \* \* \* \* \*  
 \* Moving CPU RAM into the \*  
 \* computer is a major change \*  
 \* to the TI-99/4A expansion \*  
 \* system and may cause some \*  
 \* software problems. Machine \*  
 \* language programs that use \*  
 \* SPEECH or are dependent on \*  
 \* critical timing, MAY NOT \*  
 \* operate correctly. \*  
 \* \* \* \* \*  
 \*\*\*\*\*

This project should be regarded as a 'BUDGET' MEMORY EXPANSION for the unexpanded TI-99/4A user rather than as a replacement for existing 32K expansion cards'

If you wish to add the 32K expansion but don't have a disk drive or controller, you should also be aware that the extra memory is not fully useable by cassette based users.

For instance, you may only SAVE Extended Basic programs up to 12K in size to cassette, though the programs will have a much larger operating space for arrays etc. ( You could for example, read a 12K Text file into a 12K program - If you're the patient type.... )

If you have a MINI MEMORY module the project has some interesting potential, using EXPMEM1 and EXPMEM2 and also for Machine Language programs.

Later, using the 'Westralian Instruments' MAXI MEMORY and with a battery backed 32K memory expansion on board, it will be possible to create a TI-BASIC program that utilises a 24k data file located in EXPMEM2 assisted by 8k of M/L routines ( 'Display At', 'Accept At' etc. ) located in the 'MAXI MEMORY'. If the TI-Basic program was less than 8k in size it could be saved in EXPMEM1.

EVERYTHING WOULD BE INSTANTLY AVAILABLE ON POWER UP AND WOULD OPERATE WITH THE ACCESS SPEED OF A RAM DISK'

( Although not documented, it is possible to save programs to EXPMEM1, before doing so, you must CALL LOAD( 8192,90,165 ). EXPMEM1 can also be used for data files by loading similar values to those used for EXPMEM2 into location 0194.)

Whilst pondering these 'fringe' ideas we kept hearing a ghostly chorus crying in the distance.

"TI.....OH....TI.....WHY.....DID  
 ....YOU....DESERT...US....?"

PROTOTYPE.

The project was developed on an old TI-99/4 ( without case ) and the four RAM chips were ALL 'FIGGY-BACKED' in one 28 pin socket! It was surprisingly easy to do and and took up an

unbelievably small amount of space. Hence the name 'MATCH BOX' expansion. ( TI's 32K memory expansion card uses 33 chips. )

To make it more reliable we mounted the four RAM chips in two sockets on a small piece of strip board soldered to the grom extender. This made a tight fit in the space where the speaker used to be in the old TI-99/4 computer.

To allow for future projects we have decided to mount everything on a single piece of STRIPBOARD, 23 cm. wide by 9 cm. deep and up to 2.5 cm. high, which can be mounted on ( self adhesive ) NON-CONDUCTING stand-offs, on top of the shielding covering the main computer board. ( In the empty space between the keyboard and the back of the computer. )

For 'ONE OFF' construction, stripboard is faster to use than printed circuits and cheaper than wire wrap or other connection methods. It is also permanent enough for use, whilst allowing quick alterations if necessary.

Whether you end up with a 'RATS NEST' or a neat job, depends on the care you take. If you work carefully and neatly the whole project can be finished in a few hours. Much less time than it takes to write ( or read ) this article.

Only a small portion of the board is needed for the 32k expansion and you may find it easier to mount the four RAM chips in separate sockets. This would increase the amount of wiring required but eliminate the tricky FIGGY-BACK soldering.

PARTS REQUIRED.

4 HITACHI HM6264LP-15 RAM Chips. ( For M/L use you may add them one at a time as required. )

1 piece of copper strip board. ( 34 strips wide and 23 cm. long, if you intend to add other projects later. )

2 ( or 4 ) 28 pin Chip sockets.

1 22 uF Tantalum Capacitor.

An edge connector or small plug & socket for 30 or more wires. ( We will need more wires for future projects, so use larger connector if available. )

Several Non-conducting standoffs or a sheet of insulating material to separate the strip board from the metal shielding around the computer

Coloured lengths of thin, insulated, single conductor wire for use on the stripboard

Lengths of thin, multi-stranded wire or ribbon cable to provide flexible connections between the board, Grom Extender and main computer board.

Solder, fine tipped iron, etc.

( cont. over page )

FIG.1 shows a simplified block diagram of the memory expansion. Thirteen lines of the address bus (A3 - A15), eight lines of the data bus (D0 - D7), the WE line, +5V and Earth, are all obtained by soldering wires to the back of the GROM EXTENDER.

( This is the 'GIZMO' that connects modules to the main computer board and causes all those Extended Basic lockups when not making proper contact.)

Five other lines are obtained from the TI-99/4AT Mother Board.

Believe it or not, all the decoding to separate the EIGHT 8K blocks of CPU ram is already done in the computer! The lines for the 32K expansion were just left unused.....Sheeeeeeeesh!

Four chip select lines are required for the blocks :-

LOWMEM	-	>2000 to >3FFF
HIMEMAD	-	>A000 to >BFFF
HIMEMED	-	>C000 to >DFFF
HIMEMEF	-	>E000 to >FFFF

One other line required is DBIN ( Not DBIN ) and this is also obtained from the main board.

The 'easiest' way to connect to these five lines is to solder wires ( with a fine tipped iron) directly on to the pins of the console chips. We know this is crude but it sure is easy!

What else do you expect from a TIN-FOT outfit like 'WESTRALIAN INSTRUMENTS' ??? ( When the cover is back on, no one will ever know and it will work just fine....)

To make future mods easier, bring all lines through some type of connector. One with as many pins as you can find for future projects. ( Sixty wires should be enough....) If you can only obtain smaller connectors, you can use more than one.

Mount the connector at the rear of the STRIP BOARD and use flexible wires or ribbon cable to connect between the grom extender, main computer board and the edge connector. ( It is a good idea to anchor them somehow ( ? ) to prevent movement breaking connections. )

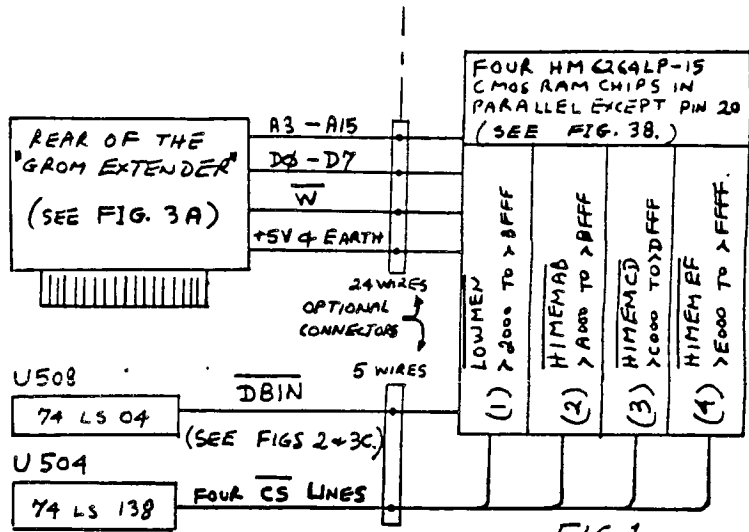
FIG. 2 shows where to connect the 5 wires on the TI-99/4AT and FIG. 3A shows the numbering of the pins at the back of the grom extender.

The complete expansion is shown in FIGS. 3A,3B,3C and tables A & B list the 29 wires needed to connect the various bus lines to the RAM sockets.

The exact layout to use is up to you. Just keep sockets as compact as possible while still allowing access for connections.

Cut the strip board where necessary to isolate active lines and be as neat as you can with your wiring. ( Thin, single conductor wires are easiest to keep neat.)

32K Matchbox Expansion ( cont. )



EXISTING  
TI-99/4A  
COMPUTER

FIG.1.  
"THE 32K MATCH BOX"  
EXPANSION.

BERNIE ELSNER AND PAUL WEST.  
'WESTRALIAN INSTRUMENTS.'

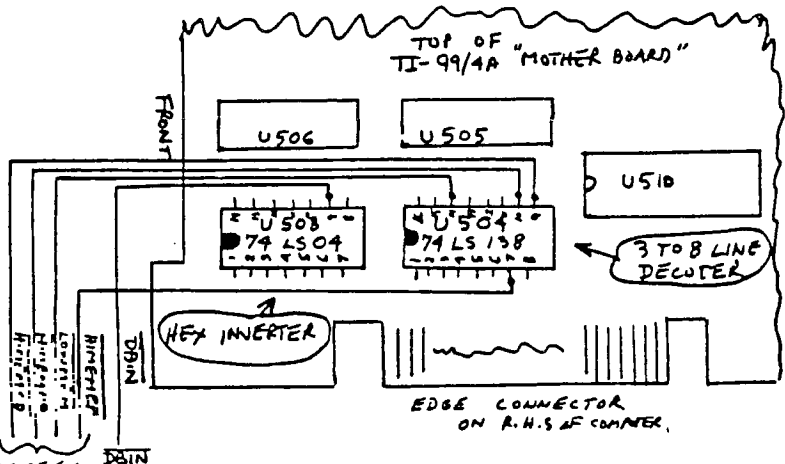


FIG.2. CONNECTIONS TO COMPUTER BOARD

8 7 6 5 4 3 2 1

A	REDRAW SCHEMATIC 25-2-85	✓	
B	FORMAL RELEASE	✓	✓

REVISIONS			
NO.	DATE	BY	REASON
1	25	W.A.	

\* REAR VIEW OF GROM "EXTENDER" SHOWING PIN NUMBERING AND FUNCTION OF THE WIRES REQUIRED BY THE MEMORY CHIPS.

		WE	A4	A5	A6	A3	A7	A8	A9	A10	A11	A12	A13	A15				DATA
36	34	32	30	28	26	24	22	20	18	16	14	12	10	8	6	4	2	+
						A14		+5V	D0	D1	D2	D3	D4	D5	D6	D7		-
35	33	31	29	27	25	23	21	19	17	15	13	11	9	7	5	3	1	

\* REAR VIEW OF GROM EXTENDER. A-INDICATES ADDRESS BUS D-INDICATES DATA BUS.

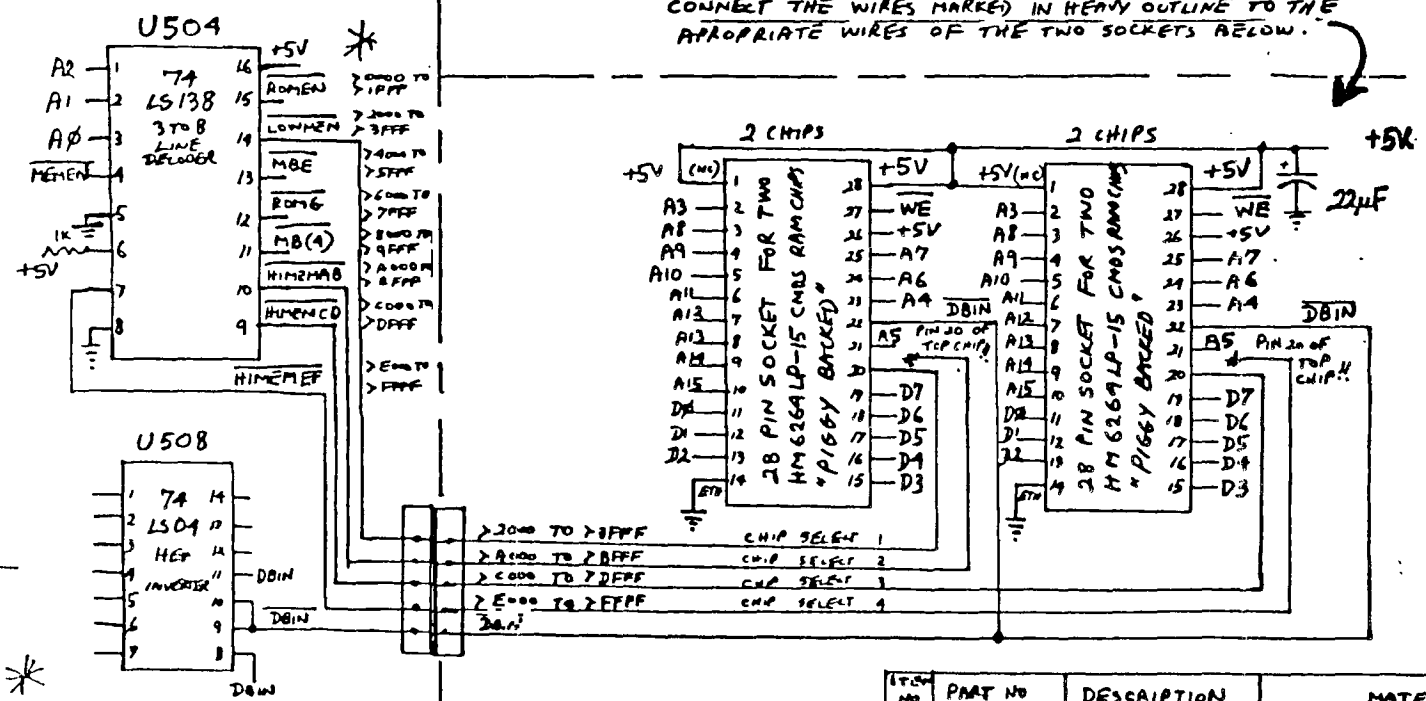
CONNECT THE WIRES MARKED IN HEAVY OUTLINE TO THE APPROPRIATE WIRES OF THE TWO SOCKETS BELOW.

CONNECTIONS TO REAR OF GROM EXTENDER

FIG. 3A.

FIG. 3C.

EXISTING TI-99/4(A) "MOTHER BOARD"



32K EXPANSION FIG. 3B.

\*  
 ROMEN ENABLES CONSOLE ROM.  
 ROMG ENABLES MODULE ART.  
 MBE ENABLES DSR ROMS  
 MB(A) ENABLES PAD.

ITEM NO	PART NO	DESCRIPTION	MATERIAL	REMARKS
	PHIL WEST		WESTALIAN INSTRUMENTS	
	BERNIE ELSNER		PROJ-01 TI-99/4 AT	
	T.I.U.P. - W.A.		32K. MATCHBOX EXP.	
	Rev. A 21-2-85		D 108539716842	3 of 3

32K Matchbox Expansion ( cont. )

TABLE - A.

WIRE NAME AND FUNCTION TI'S BUS	PIN NOS. ON REAR OF THE GROM EXTENDER	PIN No. ON BOTH RAM CHIP SOCKETS	WIRE NAME ON HITACHI RAM CHIP
+5 VOLT	19	28, 26, 1	VCC, CS2, NC
± EARTH	2	14	GND
WE <sup>WRITE</sup> ENABLE	32	27	WE
A3	29	2	A12
A4	30	23	A11
A5	28	21	A10
A6	26	24	A9
A7	22	25	A8
A8	20	3	A7
A9	18	4	A6
A10	16	5	A5
A11	14	6	A4
A12	12	7	A3
A13	10	8	A2
A14	23	9	A1
A15	8	10	A0
D0	17	11	I/O1
D1	15	12	I/O2
D2	13	13	I/O3
D3	11	15	I/O4
D4	9	16	I/O5
D5	7	17	I/O6
D6	5	18	I/O7
D7	3	19	I/O8

*Handwritten notes in table:*  
 - A bracket groups rows A3 through A15, labeled "15 WIRES OF THE ADDRESS BUS".  
 - A bracket groups rows D0 through D7, labeled "DATA BUS".

TABLE - B.

WIRE NAME + FUNCTION	FROM COMPUTER CHIP NUMBER & PIN No.	TO RAM CHIP No. & PIN No.	WIRE NAME ON HITACHI RAM CHIP
DBIN <sup>DATA BUS IN</sup>	U508 / 9 or 10	22 ON ALL	OE
LOWMEN	U504 / 14	20 ON CHIP 1	CS1
HIMEMAB	U504 / 10	20 ON CHIP 2	CS1
HIMEMCD	U504 / 9	20 ON CHIP 3	CS1
HIMEMBE	U504 / 7	20 ON CHIP 4	CS1

- NOTES
- (1) PIN No 1 ON RAM CHIPS NOT USED (CONNECT TO +5V)
  - (2) PINS 1, 4, 6, 21, 25, 27, 29, 31 AND 33 TO 36 ON GROM EXTENDER NOT USED HERE.
  - (3) TEXAS INSTRUMENTS NUMBER THEIR BUS LINES IN REVERSE ORDER TO MOST OTHER MANUFACTURERS!
  - (4) DBIN IS AVAILABLE ON GROM PIN 25 BUT WOULD NEED TO BE INVERTED TO GET DBIN
  - (5) RAM CHIPS ARE "PIGGY BACKED" IN PAIRS, OR MOUNTED INDIVIDUALLY.



32K Matchbox Expansion ( cont. )

Although we didn't use one on our prototype ( slack ) it is probably a good idea to add a 22 uF Tantalum capacitor between +5V and earth, at the sockets, to decouple the power supply.

Don't plug any RAM chips in until everything is completed and checked. Leave connection of the chip select lines ( pin 20 ) for the TOP TWO ( piggy-back ) chips till last.

Which chips eventually connect to which chip select lines doesn't matter although it's an idea to use some system so you can fault find if necessary.

When you have connected all the wires except for the two chip select lines mentioned earlier,

```

*****
#
# CHECK EVERYTHING - TWICE! #
#
*****
    
```

Check that every termination is correct and that there are no short circuits between adjacent pins or tracks.

Would you back yourself for \$100 not to make at least one mistake in 150 odd connections ???

```

***** ANOTHER WARNING *****
#
# NEVER MAKE ANY CONNECTIONS #
# OR CHIP CHANGES WITH POWER #
# CONNECTED TO, OR TURNED ON #
# AT, THE COMPUTER. ALLOW TIME #
# AFTER SWITCHING THE POWER #
# OFF FOR ALL CAPACITORS ON #
# THE POWER LINE TO DISCHARGE. #
#
*****
    
```

DON'T use all four chips at once, just try low memory on its own. If that works OK you can proceed with the others. ( ONE BLOWN CHIP IS CHEAPER THAN FOUR! )

Various precautions are advised for handling CMOS chips. We've never had problems with static electricity or lost any chips but it is probably a good idea to acquaint yourself of the correct procedures before handling your own chips.

The quickest way to try each 8K block is with 'EASY BUG' in the MINI MEMORY. If you don't have a MM then you can use Extended Basic or Editor Assembler to 'CALL INIT', 'CALL LOAD' and 'CALL PEEK' into each block of memory. If you don't have those, why go on ?

If the first block tests OK, you can 'PIGGY-BACK' the top two chips and connect their CS lines. Carefully bend pin 20 of each upper chip out at right angles and solder the CS line direct to the pin.

Do a minimum of bending to the pins and use as little solder as possible, you might want to use the chips again elsewhere.

As mentioned previously our original prototype had all four chips 'PIGGY-BACKED' in one socket. Initially the chips were NOT SOLDERED, their pins were carefully bent to exert just the right amount of tension to make firm contact with the chip below. They were then carefully aligned and placed on top of each other. Finally the chip select lines were soldered to pin 20 of each chip.

Yes I know, this article gets worse and worse as you go along. Want to buy my 32K card ???

When you have tested all four blocks, carefully solder the 27 pins ( not pin 20 ) of the top chip, to the matching pins of the lower chip of each pair.

This is the most difficult part of the whole job. If possible, practise with some cheaper chips to get the idea. Use a fine tipped soldering iron, take your time and be careful. Shaky hands are out. If you spread solder between adjacent pins use 'solder wick' to remove it.

If any pin fails to make contact with its lower partner or short circuits to a neighbour you will end up with some nasty faults to find...or worse...COOKED CHIPS!

That was added just to get your hands shaking.....

POWER CONSUMPTION.

The +5V power supply of OUR TI-99/4 & 4A computers proved to be capable of supplying the extra load of the 32K expansion. If you modify your computer you should verify that YOUR power supply can also support the added load.

CMOS RAM chips mainly use power when they are being 'ACCESSED' or 'CHANGING STATE' therefore only ONE chip at a time, will present any significant load to the power supply.

Data sheets for the HM6264LP RAM chips state that the typical operating current consumption is 60 mA ( 110 mA MAX. )

Load on the +5V supply varies depending on whether the SPEECH SYNTHESIZER is attached, which module is plugged in. ( the Extended Basic module appears to use most power ) and which particular function is being performed by the processor.

We measured current drain on the +5V supply with a digital meter to get some idea of the average ( NOT PEAK ) current consumption and obtained the following results.

Bare Console	925 mA
Extended Basic Module	90 mA
Speech Synthesizer	45 mA
-----	
Total	1060 mA
-----	

We then measured the 'average' extra current used by the 32K memory expansion, whilst using the computer for some typical tasks. ( When idle the 32K

expansion produced a negligible load of 25 Micro Amps. )

Using Disk Manager ---	1 to 4 mA
TI-WRITER Loaded, Idle ---	2 mA
" " " Loading Text ---	7 mA
" " " Key Pressed ---	19 mA
" " " Finding Strings	21 mA
Ext. Basic Run Music Prog.	19 mA
M/L Program 'Locked up' --	28 mA

At no stage did the measured EXTRA current exceed 30 mA or 3% of the maximum total unexpanded consumption.

Whilst these figures are not claimed to be comprehensive or accurate, they indicate that the power supply of the computer should be able to cope with the extra load of the RAM chips for most applications.

In our next article we will provide details of a reliable non-corrupting, self charging battery backup for the full 32k expansion.

CONCLUSION.

-----  
 We would like to hear from other TI-99/4A users who have created useful mods for their computers and expansion systems or from anyone with ideas for other hardware improvements, in the 'PRACTICAL - TO - CRAZY' range.

In return we will put you on the mailing list for details of our future projects. Write to :-

'WESTRALIAN INSTRUMENTS.'  
 P.O. Box: 246, Mt. Lawley,  
 WESTERN Australia, 6050.  
 ( Home of the America's Cup! )

TEL.092718642. SOURCE-ID TI0147

This project provided a great deal of enjoyment for the staff at WESTRALIAN INSTRUMENTS and we hope that anyone attempting it, will receive the same thrill we did, when we typed 'SIZE' in Extended Basic and received the message :-

13928 Bytes of Stack Free  
 24488 Bytes Program Space Free

Not to mention the satisfaction from being able to use TI-LOGO with 'JUST' a console, monitor and cassette recorder.

GOOD LUCK !!!

Bernie Elsner and Phil West.

Editor's Comment

Great stuff Bernie and Phil !! I think that there are many TI users who will benefit from this article. I look forward to reading your future articles devoted to hardware modifications.

This article would have won my prize for the best submission for this newsletter had it been on time. Still, if I don't get any entries for the 'Editor' program competition that I am running, you can share half a 'Car Wars' module each for this effort.

computer fleamarkets

If you've never been to one, try one out. Stuff is offered 'as is' but the price is right: TEAC double-side drives for \$65 (asking price), parts galore, disks at 85 cents with sleeves and preflipped! Stuff and prices to boggle the mind: I got a TI 990 board for \$10 (marked down to \$150 from 270, retail \$590 or so.) John Stover got an RS232 80 column terminal for \$35, that he can use with a modem (by itself, no 99/4A) to call up BBS's. He probably can use FORTH in the SWCH mode and have a true 80 column editor/system.

disemblers. thud.

Response to the Disembler's project\* has been underwhelming. Be that as it may, some figures about our facts: Our EQUate list identifies some 246 different names and locations (fewer, some are named twice or more). PAD's documentation presently takes up about two and half pages, just listing EQU names and their references. The machine-dependent jump table (partial) contains some 40 different addresses. All told, the memory map documentation is up to nine pages.

\*Disemblers: we're trying to document the operating system. By breaking the console ROM down to pages of 256 bytes and letting individuals, groups and so on have-at just one page, the project is feasible. The EQUate list ensures that we're talking about the same locations in the operating system.

Interested participants are invited to write to me, either care of the Lehigh 99'er or at 1020 N 6th Street Allentown, PA 18102. Send a SASE, a SSSD disk with return postage and packaging. Because response is so limited, the list of participants will be made available August 1st. (There's still time to join in.) What you'll need: interest, some assembly experience and a willingness to chase down the OS. By the way, the project results is limited to the original participants, who do with the documentation as they wish.  
>Frederick Hawkins

~~~~~  
**LEHIGH 99'ER COMPUTER GROUP**

P.O.Box 4837 \* 1501 Lehigh St.  
Allentown, Penna. 18103

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