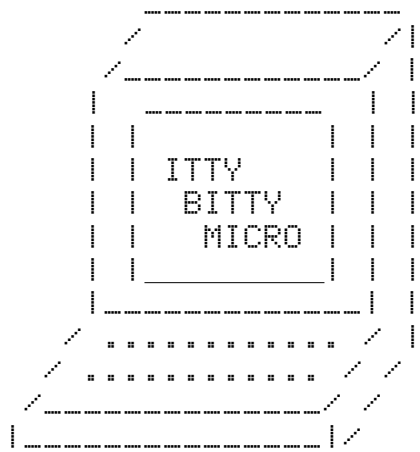
Itty Bitty Micro Company
8080 Future Drive
Rochester, NY 14650



January 22, 1980

Dear Wiz,

I know, I know... the West Coast Computer Faire is coming up FAST! You SAID you're on vacation; but I KNOW you, man! You're probably still at home, hacking on that PDP-8 you got at the hamfest.

Well, forget that old crap. THIS IS IMPORTANT! The boards for "Project Z" arrived. PLEASE get them assembled and working NOW! If we don't have something INCREDIBLE for the show, we're dead! I already talked to Jim Warren, and got a great booth at the show, right across from Heathkit.

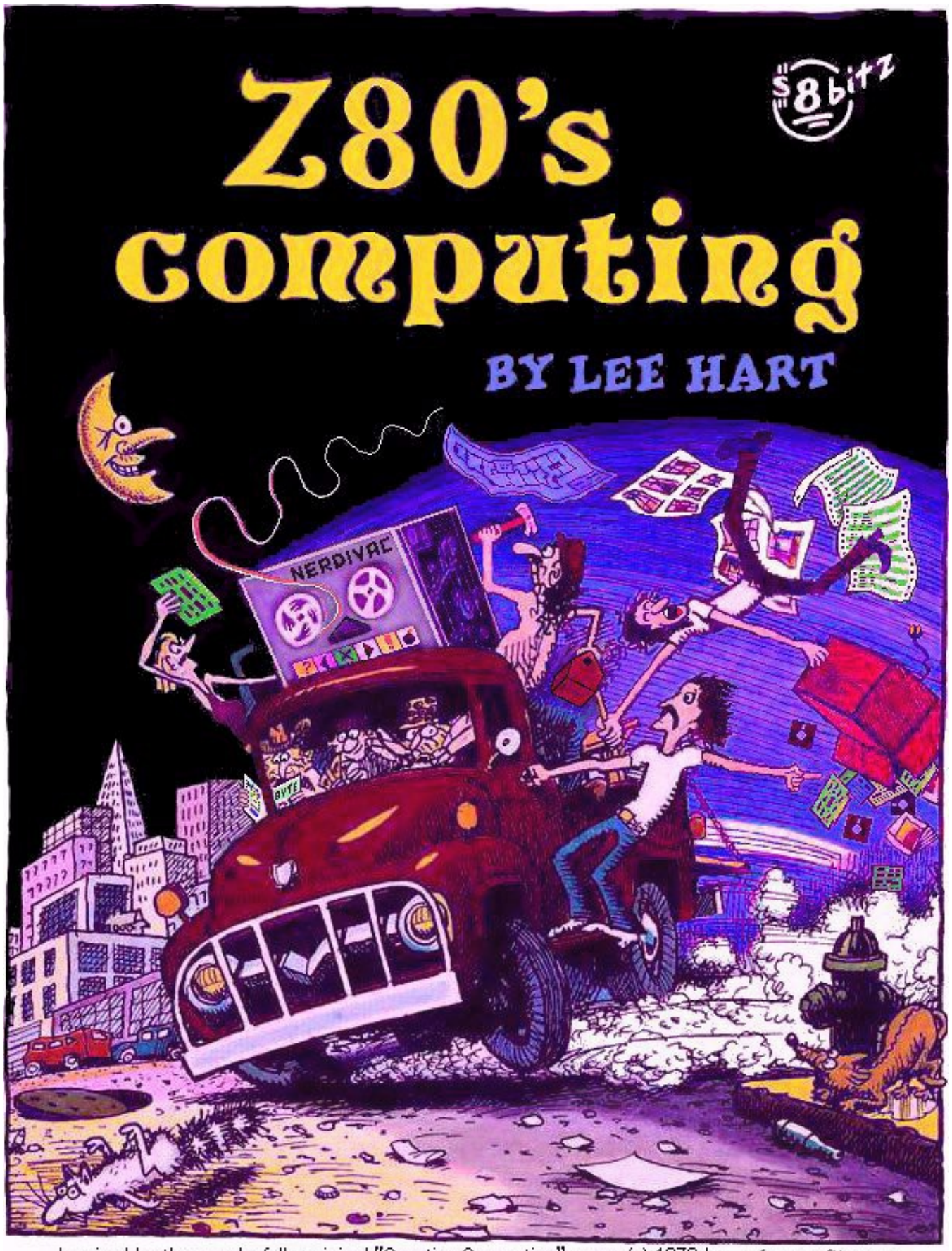
I put everything in the box we could find. You've got the boards (aren't they GORGEOUS?), all the parts (I hope!), and every scrap of paper Chip thought you might need. Crash also burned his latest monitor program into the EPROM, and wrote some docs on it.

Remember, this is going to be the world's first POCKET COMPUTER! There's no time to get a custom case; so for now just stick it in an Altoids tin. It's a hacker classic, and "everyone knows" you can't make a computer that small (but WE can)! In a world full of big beige boxes, we've got something people will REMEMBER! This is going to be SO much more powerful than your little "**Altaid 8800**" (that Altair 8080 in a Altoids tin)!

Yours truly,

Gil Bates
Emperor of Marketing
Itty Bitty Micro Company

cc: Chip Hacker, hardware herder
Crash Kernigan, codemeister
Wiz Wireman, solderking
Trace Weaver, PCB artiste



Inspired by the wonderfully original "Creative Computing" cover (c) 1979 by GILBERT SHELTON

Introduction

January 1975. My gawd; was it really 40 years ago that the microcomputer revolution began? It was the tipping point of momentous events. You could ***see*** the world changing right before your very eyes. America had just put men on the moon, and the Arab Oil Embargo had shown us that oil was not forever. And there on the cover of the January issue of Popular Electronics magazine was the MITS Altair 8800; a computer you could build yourself for only $400.

I was just out of college with a fresh BSEE degree; idealistic, enthusiastic, and out to change the world. I went to work for Eastman Kodak in Rochester NY. They told me how wonderful the company was, that film was forever, and that they were the most advanced imaging company in the world.

But when I saw their old tube and relay circuits from the 50's, it reminded me of a story. Two shoe salesmen arrive in a remote village where everyone goes barefoot. The first salesman writes back, "Situation hopeless. They don't wear shoes". The second salesman writes, "Prospects unlimited. No one has shoes yet." I figured Kodak needed shoes; so I set out to make 'em.

By day, I worked inside the system, seeking to reform the dinosaur from within. The other young EEs and I built digital cameras with a CCD imaging chip. We stored photo albums on audio cassette tapes, and displayed them on a TV set. We modified photocopiers to print text received from a serial port. We built systems to replace the messy chemical processing and costly silver with clean modern efficient electronics. That didn't work out so well. At every turn, management said the electronics weren't good enough and that film will always be better.

So by night, I built my own computers. And I conspired with other eager experimenters working at Kodak, 3M, Xerox, Rochester Institute of Technology, and the other high-tech outfits in the area. We ***knew*** the world was changing fast! Microcomputers were exactly the right tool to do it. And we were a part of it. We were inventing the future!

This is the true (*) story of the computer we made. Or could have made back then, if we'd been just a little smarter, or luckier, or worked a little harder, or had a little more nerve... or had found ***you*** to help!

But now ***you*** are part of the team. You've picked up the Altaid 8800 Project where we left off. Build it, test it, then invent your own incredible new gadgets. Show us what ***could*** have been done way back then, if we'd only known then what we know now. C'mon – we're depending on you!

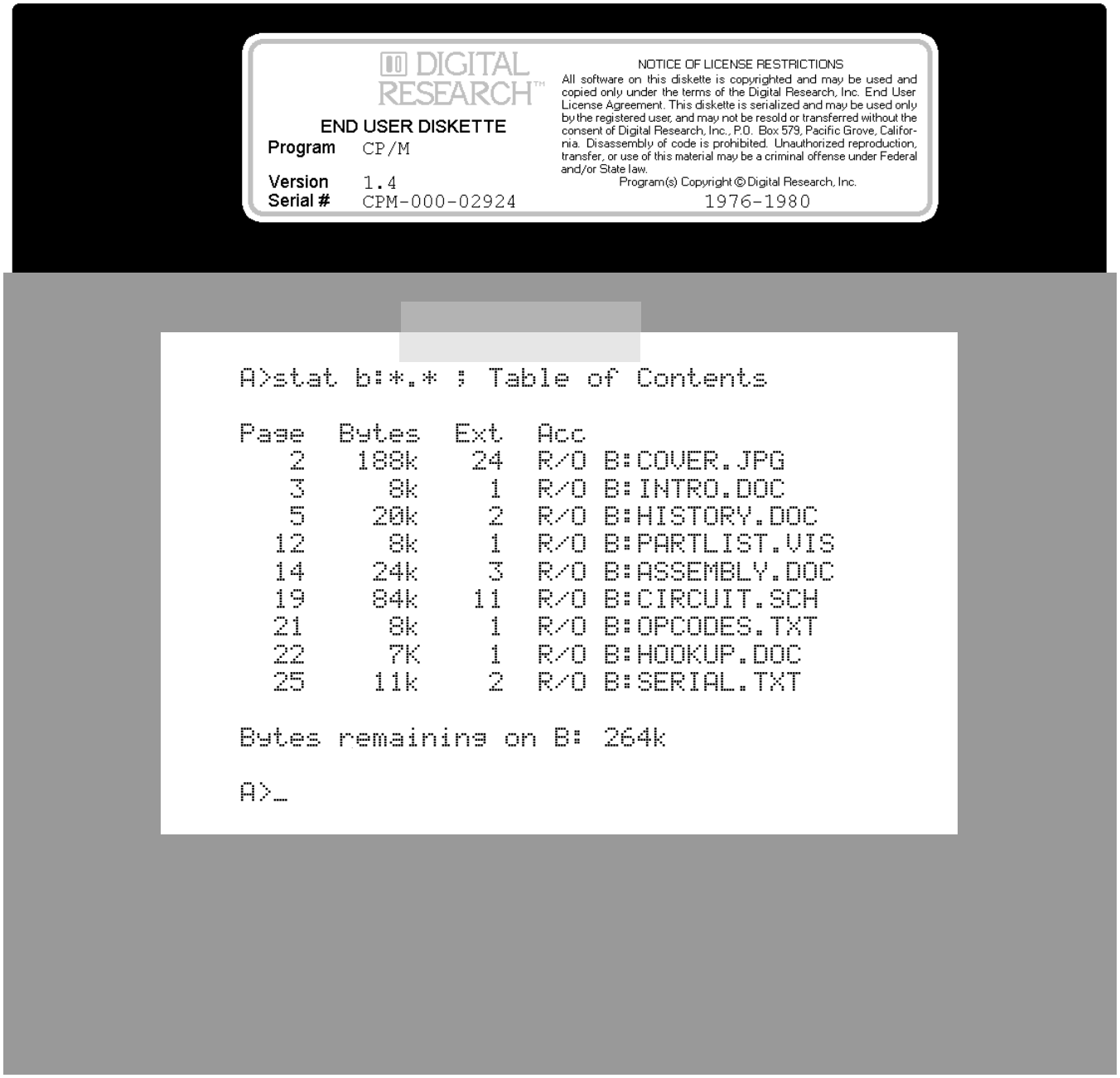
TMSI c/o Lee A. Hart
814 8th Ave N, Sartell MN 56377, USA
(320) 656-9574

leeahart@earthlink.net
http://www.sunrise-ev.com/z80.htm
Z80MC Yahoo group: Z8MC@yahoogroups.com

Rev.BD – 3 Oct 2019

--
* OK; so it's only partly true. Hey, I'm an old man now! My forgetory is better than my memory. I may have changed a few names, dates, details, facts, or even made some things up entirely. Sometimes the facts alone don't tell the whole truth, so a little artistic license is needed to communicate the ***real*** story.

Warning: May contain nuts.



Wiz,

Here's an 8" floppy disk with all the "Project Z" files. It holds up to 1.2 megabytes depending on formatting (single- or double-sided; single-, double-, or extended-density). That's a LOT for 8-bit software. Hey; this is the high-tech way to do software development in the 1970's!

Yeah, a hard disk would be nice; but then I couldn't send it to you. Besides, they are insanely expensive. Hobbyists or even small outfits like us can't afford them. Good thing we're not REALLY poor, or we'd be saving programs on cassette tapes!

It's a CP/M disk. CP/M is the most popular microcomputer disk operating system around. It's so popular that I hear IBM's PC-DOS is actually a copy of CP/M. If the disk is missing, or you can't read 8" disks, you can download the files from our BBS at http://www.sunrise-ev.com/z80.htm

Crash

HOW TO "READ" FM TUNER SPECIFICATIONS

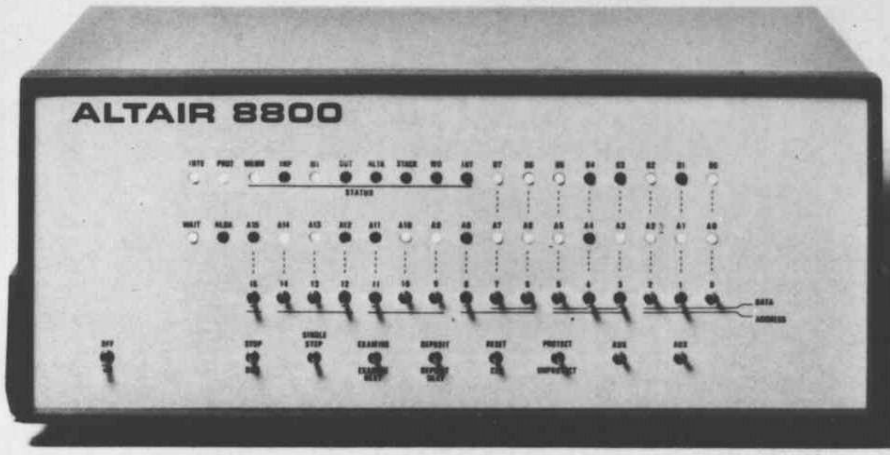
Popular Electronics

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE JANUARY 1975/75¢

PROJECT BREAKTHROUGH!

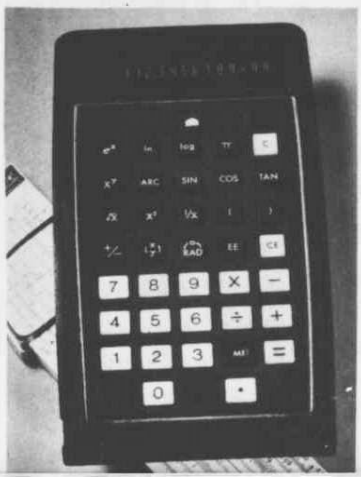
World's First Minicomputer Kit to Rival Commercial Models...

"ALTAIR 8800" SAVE OVER $1000



ALSO IN THIS ISSUE:

- An Under-$90



Advanced Abacus Associates

Subject: Altair 8800 !!!

To: Chip Hacker

From: Gil Bates

Did you see THIS? The kit is only $400! Forget that MARK-8 from Radio Electronics. The 8008 is only half a CPU. This has an 8080. It's a REAL computer, man! This is going to be BIG! I hate my dead-end job (and so do you). So let's

1975 C38080 JMP FUTURE ; NOW!

Jan 11, 1975

Hi Gil,

Yeah, I saw it. Interesting! But is it real? They never show the insides; just a shot of the front panel boards. Seems like an awful lot of parts. 58 ICs... in a $400 kit? Intel lists the 8080 for $360, and the 8111 256x4 RAMs are $26 apiece! Sounds too good to be true. But, I sent for ~~literatur~~ more information. Let's see what we get.

Before we board this Titanic, may I remind you that it was YOU who talked me into buying the Mark-8 boards? I've got $400 in it, and it will take another $400 to get it to do anything more than blink LEDs. It's more like a bicycle with training wheels than a computer.

And before that, you got me to buy those calculator chips for $300. Weren't we going to make a killing selling scientific calculators?

Yours tr~~l~~uly, Chip

February 1, 1975

Chip,

HP was selling their HP35 scientific calcluator for $395 at the time. We bought 10 of those MOS Technology chips for $30 each. And you did build a great desktop calculator with them! But it took a year to get it done. By that time, you could buy a Sinclair Scientific for $100. We were right; but too slow!

Still, we did sell enough to brake even. And you got a great calculator out of it. You learned a lot~~s~~, and I'll bet you used it a million times, designing circuits and stuff. Money spent on brains and tools is well spent. Am I right?

Tell you what. I'll BUY the~~y~~ Mark-8 from you for $400. Use the money to by the Altair. The Mark-8 will be collectible someday; so I'll probalby make a profit!

Your Fiend, Gil

Feb 20, 1975

Dear "Fiend",

You're right, of course. (Even a broken clock is right twice a day.) Against my better judgement you talked me into it. As discussed by phone, I'll pack up the Mark-8 and send it to you. But before you put it in a glass case and sell it to some museum, PLEASE let me show you the neat things it can do!

I got the literature from MITS on the Altair 8800. Their "System #1" is now $542... and that's a minimum system, with only a front panel and 256 bytes of RAM (same as the Mark-8). It has an expansion bus that sounds great; but their accessory boards are expensive!

I thkink the way to go is buy their minimum system kit, and build my own memory an I/O boards. Theirs are WAY over-priced! (Like you said, they sell the razors cheap, and make up for it on the blades).

so I placed my order today!

Anxiously awaiting it,
Chip Hacker

JUNE 2, 1975

DEAR GIL,

SORRY FOR NOT WRITING. I'VE BEEN BUSY! IT TOOK MONTHS, BUT THE ALTAIR ARRIVED. THIS AIN'T NO HEATHKIT. IT TOOK A WEEK TO BUILD. POOR MANUAL, LOTS OF HAND WIRING (60 WIRES TO THE FRONT PANEL, 100 TO THE EXPANDER BOARD). AFTER FIXING MISTAKES AND REPLACING SOME BAD PARTS, I FLIPPED THE SWITCHES TO LOAD A PROGRAM AND IT WORKS! IF WE DO BUILD A PRODUCT, IT'S -GOT- TO HAVE A GOOD MANUAL AND BE SIMPLE TO BUILD.

I ALSO GOT A TERMINAL... A MODEL 19 ASR BAUDOT TELETYPE! UPPER CASE ONLY, BUT IT HAS A PAPER TAPE READER/PUNCH (THAT NEEDS FIXING). MY FIRST PROJECT WAS TO INTERFACE IT TO THE ALTAIR.

OK SO YOU WERE RIGHT AGAIN. THE ALTAIR -HAS- BECOME POPULAR, AND IS WAY BETTER THAN THE MARK-8. BUT PIECE BY PIECE, I THINK I'M GOING TO REBUILD EVERY PART OF IT. ITS BETTER BECAUSE I KEEP IMPROVING IT.

EVEN WITH THE MEMORY BOARD FILLED TO 1K, THERES NOT ENOUGH TO DO MUCH. I GOT MY BAUDOT PRINTER DRIVER WORKING, BUT WITH IT LOADED THERES NOT ENOUGH ROOM FOR EVEN A MACHINE-LEVEL MONITOR. I HAVE TO TOGGLE IN A LOADER, THEN IT CAN LOAD A PAPER TAPE WITH A PROGRAM. BUT THAT TAPE HAS TO INCLUDE A PUNCH PROGRAM IF I EXPECT TO SAVE ANYTHING TO LOAD LATER.

I GOT A PROTOBOARD AND WIRE-WRAPPED MY SERIAL INTERFACE. ITS JUST A PARALLEL PORT, TO BIT-BANG SERIAL DATA FOR THE TELETYPE. THERE WAS LOADS OF ROOM, SO I ADDED A 1702 EROM SOCKET. I PROGRAMMED IT AT WORK, SO NO MORE TOGGLING IN LOADERS AND HOPING THE PROGRAM WONT' CRASH, OR WORRYING THAT THE POWER FAILS AND I LOSE IT ALL.

I WAS GOING TO BUILD A MEMORY BOARD, BUT DIDN'T HAVE TO. I HEAR MITS BOARDS ARE TROUBLE, BUT THERE ARE ALREAADY LOTS OF OTHERS ON THE MARKET! MEMORY PRICES ARE DROPPING LIKE LEAVES IN FALL. FOR $195 I GOT A 4K RAM BOARD FROM PROCESSOR TECHNOLOGY.

OF COURSE WITH ALL THIS, I HAD TO UPGRADE THE POWER SUPPLY. I'M ALSO OUT OF CARD SLOTS, AND WILL HAVE TO ADD ANOTHER EXPANDE RBOARD TO GO MUCH FURTHER. WANNA BUY AN ALTAIR FOR YOUR COLLECTION? THE IMSAI 8080, WITH ITS BIG MOTHERBOARD AND POWER SUPPLY IS LOOKING PRETTY GOOD RIGHT NOW.

CHIP

June 8, 1975

Hi Chip!

Good to hear from you, man. I thought you died! But I see you're in turtle mode again... your head down and puttering slowly and methodically away, while the world madly races ahead. You do absolutely brilliant work; but it takes you forever.

Have you found anything we can make for the Altair market (that someone ELSE isn't already doing)? Not memory boards, not BASIC... that's already been done! You want to sell me the Altair? Then make it DO SOMETHING that someone ELSE (other than you) would love! How about this... a memory board but with BASIC already in ROM, so it's there the instant you turn it on. The BASIC can be "FREE" (not $150 like Altair BASIC) if it's on a $150 memory board!

Impatiently yours,
Gil Bates

JUNE 22, 1975

HI GIL,

BASIC IN ROM WOULD BE COOL! I CAN BUILD THE BOARD BUT I'M NO PROGRAMMER. KNOW ANY GOOD ONES? THEY'RE STARTING A COMPUTER CLUB (R.A.M.S. FOR ROCHESTER AREA MICROCOMPUTER SOCIETY). I'LL START ASKING AROUND.

MEANWHILE, I CAN SEE THAT A ROM BOARD WOULD BE GREAT. IT WOULD SAVE HOURS OF LOADING WITH PAPER TAPE (AND MY PUNCH IS STILL GIVING ME TROUBLE). SO, I STARTED ON A ROM BOARD. ALTAIR BASIC IS 4K, SO WE'LL NEED 16 1702'S. MAN, THAT'S GOING TO BE EXPENSIVE.

CHIP

Aug 75

Hi Chip!

Summer is nuts here. The old farts go on vacation, so I'm WAY busy. (They all get 6 weeks; I only get a lousy 2, and have to take it when none of them want it).

Don't worry about prices. They will come down FAST! Have you heard of Moore's Law? Gordon Moore at Intel says they can put TWICE the transistors on a chip every year. That means chip prices should fall by 2:1 a year. Or more! That 8080 that was $360 in Jan is now $75! You watch: Those $30 1702s will be $10 by Christmas.

So work like hell on that ROM board! Even if we can't sell it, you'll have a replacement for that flakey old teletype.

o o
Gil Bates __/

OCT 7 1975

DEAR GIL,

GOT THE PARTS, AND WIRE-WRAPPED MY ROM BOARD. THE 1702 IS A MIGHTY ODD DUCK. READING IT IS BAD, BUT PROGRAMMING IT IS WORSE! AND THE BOARD HAS TO BE ABLE TO PROGRAM IT, OR THERE WON'T BE ANY WAY FOR A CUSTOMER TO GET HIS CODE INTO IT.

INTERFACING TO THE ALTAIR BUS IS A MESS. THEY JUST INVENTED IT AS THEY WENT, WITHOUT MUCH PLANNING. IT TOOK 12 ICS TO SUPPORT JUST 2 EPROMS. BUT IT WORKS! TODAY, I PROGRAMMED MY TELETYPE DRIVER INTO ONE AND AM USING IT NOW!

WENT TO THE RAMS MEETING. AMAZINGLY, THERE WAS ANOTHER ALTAIR! A PROF AT RIT DEMOED ONE HE BOUGHT FOR HIS LAB. HE GOT ALTAIR BASIC FOR IT, AND SAID HE'LL PUNCH A COPY OF THE TAPE FOR ME! BUT HIS TELETYPE IS ASCII AND MINE IS BAUDOT. NOT SURE HOW I'LL READ IT.

PS: YOU NEED A NAPOLEON HAT FOR YOUR TYPEWRITER ART SELF PORTRAIT.

CHIP

Oct 75

Hi Chip,

Great to hear it, man! I knew you could do it. The RIT connection sound great. Maybe he could be our first customer? See if he'd like a ROM board for his Altair. (Putting on my marketing hat).

_/___
Gil o o
__/

NOV 11 1975

GIL,

THINGS ARE HAPENING! I WORK ALL DAY, THEN COME HOME AND COMPUTE TIL 1AM, THEN DO IT ALL AGAIN. "CRASH" APPLIES TO MORE THAN COMPUTERS.

THE PROF AT RIT HAS A GREAT SETUP. HE GOT EVERYTHING MITS HAD AVAILABLE (WHICH IS AOBUT HALF WHATS IN THEIR CATALOG). TOOK FOREVER TO ARRIVE (AND HE'S STILL WAITING FOR STUFF).

I TOOK MY ALTAIR OVER THERE, AND SHOWED HIM MY ROM BOARD. HE LOVED IT! I OFFERED TO MAKE ONE FOR HIM, AND HE'LL PUT BASIC IN THE ROMS AND GIVE A SET TO ME.

YEAH YEAH, I CAN HEAR YOU NOW. "YOU GAVE IT AWAY FOR FREE? IDIOT!" BUT THINK... THERE'S NO WAY 2 GUYS IN A GARAGE CAN GET A PURCHASE ORDER FROM THE U. BESIDES, THEY TAKE MONTHS TO PAY. BUT HE IS GIVING ME BASIC, AND THE ROMS! THATS OVER $200 WORTH OF IC'S ALONE!

CHIP(PING AWAY AT IT)

Dec 2, 1975

Chip,

That's fantastic! No, I think you're using your head. You're actually DELIVERING something, AND to an important client that can do lots of good things for us.
Pogo: "Brains is better'n money, 'cause brains'll GIT you money."
Albert: "Yeah? Who's buyin? I got brains I never use!"

On purchase orders: We ARE going to have to set up a company to look professional. I'll get working on it!

```
                    _______
                   /______/|
Gil               | ::::::||  (look, it's an Altair!)
                  |. :::::|/
```

PS: SD Sales has 1702's for $6.95 in the Jan 1976 BYTE. See? Moore's Law rules!

JAN 16, 1976

MERRY CHRISTMAS, AND HAPPY NEW YEAR!

MY PRESENT WAS THAT I GOT MY NEW ROM BOARD WORKING. MANY IMPROVEMENTS OVER THE 1ST ONE. I LUGGED MY SYSTEM OVER TO RIT LAST NIGHT, AND WE WORKED ON IT TIL 1AM. I WROTE A UTILITY TO TRANSFER BASIC BY LOADING THE ASCII TAPE WITH HIS TELETYPE, AND SAVING IT AS BAUDOT TO MY PUNCH. IT DIDN'T WORK...

BUT THE NEW ROM BOARD DID WORK! SO WE LOADED BASIC IN HIS ALTAIR, THEN TOGGLED IN MY BURNER CODE, AND PROGRAMMED A SET OF EPROMS FOR HIM. BUT IT WOULDN'T RUN FROM ROM FOR SOME REASON. HE HAD A HOT STUDENT THERE, WHO WAS STILL HACKING ON IT WHEN I HAD TO LEAVE.

SO TODAY HE CALLED. IT WORKS! HE JUST HAD TO PATCH THE I/O AND RAM STARTING ADDRESSES. AND, HE BURNED A SET OF ROMS FOR ME. I PICKED 'EM UP AFTER WORK, AND COULDN'T WAIT TO INSTALL THEM. IT TOOK ME A WHILE TO MODIFY MY BAUDOT DRIVER TO WORK WITH IT... BUT THEN BASIC CAME UP!

THE ONLY PROBLEM (AFTER A QUICK TEST) IS THAT BAUDOT IS MISSING MANY PUNCTUATION CHARACTERS THAT BASIC USES. NOT SURE HOW I'LL DEAL WITH THAT. BUT I JUST HAD TO WRITE AND TELL YOU THE NEWS!

CHIP

Jan 26, 1976

Hi Chip,

I had a GREAT time at your place last weekend! Thanks so much for putting up with me. It's INCREDIBLE that you built a computer more powerful than Apollo's AGC-1 that flew men to the moon! The contrast between it and your clattering old WW2 veeblefetzer of a printer is particularly striking.

I apologize again for monopolizing your computer all day... and all night... and most of the next day. I almost got my stock-picker program working, but ran out of memory. It's just so friggin' AMAZING to have a machine that you can actually program to do what you want RIGHT NOW, without having to wait in line or submit your deck to be run overnight. The possibilities are ENDLESS! Have you read Ted Nelson's "Computer Lib / Dream Machines" yet? We are living in the future RIGHT NOW!

Can we commercialize your ROM board? Please? NOW? People are DYING to get computers that work as well as yours (me included). This is an expensive hobby; to go anyplace, we need to find SOME way to pay for it.

I got a name for our company. How about Itty Bitty Micro Company? That pretty much describes us. And the initials are "IBM".

```
      o o
Gil  \___/
```

19 MARCH 1976

HI GIL,

MY ROM BOARD IS JUST A DEVELOPMENT TOOL... A TOOL YOU HAVE TO MAKE FIRST, TO BUILD THE THINGS YOU REALLY NEED. LOTSA PROBLEMS SELLING IT:

1. 1702'S ARE TOO SMALL; TAKES TOO MANY. THERE'S A NEW 2708 CHIP THATS BETTER. 4 TIMES BIGGER, MUCH EASIER TO USE. AND IT HAS SPARE PINS, SO EVEN BETTER VERSIONS ARE COMING (THAT MOORE'S LAW THING).
2. IT COSTS LIKE $1000 TO GET A PCB LAID OUT AND BUILT. WE DON'T HAVE THAT KIND OF MONEY! CAN WE FIND SOMEONE WHOSE GOOD AT IT THAT MIGHT WORK IN TRADE FOR A COMPUTER?
3. WE CAN'T SELL ALTAIR'S BASIC. (DID YOU SEE BILL GATES OPEN LETTER? PIRACY, LAWYERS, JAIL!) WE HAVE TO FIND ONE OF OUR OWN. BUT GUYS ARE WORKING ON A PUBLIC-DOMAIN BASIC. PEOPLE'S COMPUTER COMPANY IS WORKING ON EXACTLY THAT!
4. YOU'RE RIGHT... THINGS ARE MOVING FAST! BY THE TIME WE SOLVE THESE ISSUES, A DOZEN OTHER GUYS WILL ALREADY BE SELLING ROM BOARDS. WE HAVE TO THINK AHEAD, AND FIGURE OUT WHAT WILL HAPPEN NEXT, AND THEN BUILD THAT.

I THINK WE NEED TO WALK BEFORE WE RUN. KEEP LEARNING, AND BUILDING TOOLS. YES, WE NEED MORE MEMORY. BUT LET OTHER PEOPLE BUILD ROM AND RAM BOARDS FOR US. THAT'S WHAT EVERYONE ELSE IS ALREADY MAKING.

RICHIE KERNIGAN (THE RIT GUY THAT GOT MY BASIC WORKING) IS A SOFTWARE GENIUS. HE MEMORIZED THE OPCODES AND ASSEMBLES CODE IN HIS HEAD! I'M BUILDING A COMPUTER FOR HIM, AND HE'S WRITING THE CODE FOR ME.

WE'RE WORKING ON SOMETHING YOU'LL LIKE. IT'S LIKE DON LANCASTER'S "TV TYPEWRITER", BUT IT WILL DISPLAY A SECTION OF THE COMPUTER'S MEMORY ON A TV SCREEN. WAY FASTER, CHEAPER, AND SIMPLER! WE THINK SOME KIND OF COMBINED COMPUTER AND TV TYPEWRITER IS THE WAY TO GO!

CHIP

(More history to follow. But jumping ahead...)

SUBJECT: Parts List
DATE: 23 January 1980
FROM: chip8080 [71323,0142]
TO: wizwireman [72404,1991]

Wiz,

Gil says to send you a set of boards and parts. OK, I mailed it out today... hopefully to the right address! Knowing you, if it arrives by noon it will be built by midnite. I swear, you wire things faster than I can draw the schematics.

Two boards; so two bags of parts, and two Visicalc parts lists. Keep them separate, as each board has the same designators (C1, R1, U1, etc.) for DIFFERENT parts. Don't mix 'em up, or debugging will be "entertaining"!

"Source" shows replacement parts; but I sent what I had on hand. That means some parts are different from the "source" numbers. No worries, mate! We built two with these parts, and they WORK! Check the resistors with an ohmmeter if you're not sure it's the right value. Here are the substitutions I can think of right now.

CPU board (rev.B) now has **TWO** ways to power it. The instructions describe way #1.

1. Power from P4 on the Front Panel. Install 5v regulator U8 with its metal tab **UP**. U8 is an L4941BV low dropout regulator; better than the 7805.
2. Power from P4 on the CPU board: Use this for the CPU board alone, with no other boards. Do not install 5v regulator U8; install P4 in its place. Short U8 pins 1-3 (the outer pins). Short P3 pins 1-2 (next to P4).

Front Panel (rev.D): I sent three 10-pin sockets for J1-J3. Cut one to make a 4-pin and two 2-pin sockets. The 2-pin pieces are "feet" to support the corners. I changed U5 from a photoresistor to a darlington optocoupler. Y2 is a 1" diameter brass disk, with a wire soldered to it.

I included a Jameco ad, with pictures and notes to identify the parts. Also prices; but it's from an old issue of "Byte" magazine so they have changed a bit. Between the ad and parts list, you'll figure it out. Yell if you have questions!

--
Chip Hacker | "There ain't no rules around here.
Chief (and only) engineer | We're trying to accomplish something!"
Itty Bitty Micro Company | Thomas A. Edison

SUBJECT: Re: Parts for Project Z
DATE: 27 January 1980
FROM: wizwireman [72404,1991]
TO: chip8080 [71323,0142]

Got yer email, Chip. Will let you know when the package arrives.

Any assembly instructions? You want it done fast, or cheap, or right? Pick one. If "fast", I've got just the kid to do it!

--
Willard Wireman
Senior Technician
Eastern Coat Rack Company
"A future to hang your hat on"

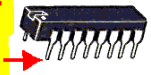
	Z80 MEMBERSHIP CARD -- PARTS LIST			
	A	B	C	D
1	QTY	ITEM	DESCRIPTION	SOURCE
2	---	----	----------	----------
3	1	C1	capacitor 4.7uF 16vdc tantalum	J 94035
4	1	C2	capacitor 33uF 10vdc electrolytic	D 493-1730-ND
5	3	C3-5	capacitor 0.1uF 50v X7R ceramic 0.1"LS	J 1570161
6	1	C6	capacitor 0.1uF X7R ceramic 0.2"LS	J 544921
7	2	P1,2	header 30-pin 0.025"sq pins 0.1"LS	J 103342
8	2	R1,2	resistor 1 meg 5% 1/4w carbon film	J 691585
9	1	R3	resistor 2.2K x 5 10-pin SIP isolated	D 4610X-2-222LF-ND
10	1	R4	resistor 2.2K x 7 8-pin SIP bussed	D 4608X-1-222LF-ND
11	1	R5	resistor 2.2K x 3 6-pin SIP isolated	D 4606X-2-222LF-ND
12	1	U1	Z80A CPU NMOS (or Z84C00 CMOS)	J 35596
13	1	U1s	socket 40-pin IC low height	D ED5640-ND
14	1	U2	32K x 8 RAM (62256 etc; CXK58257 supplied)	J 42850
15	1	U3	32K x 8 EPROM (programmed with ZMC v1.5)	J 39731
16	2	U2s,U3s	socket 28-pin IC low height	D ED5628-ND
17	1	U4	74HC368 hex tri-state inverter	D 296-33074-5-ND
18	1	U5	74HC138 3-to-8 decoder	J 45330
19	1	U6	74HC273 octal D flip-flop	J 45743
20	1	U7	74HC245 octal transceiver	J 45671
21	1	U8	L4941BV or LM7805CT 5v 1 amp regulator	J 107182
22	1	Y1	resonator 4 MHz with capacitors	D 490-1208-ND
23	1	PCB	Z80 Membership Card PC board, rev.B	TMSI (that's me!)
24	1	CASE	Altoids candy tin	candy store

	Z80 MEMBERSHIP CARD FRONT PANEL -- PARTS LIST			
	A	B	C	D
1	QTY	ITEM	DESCRIPTION	SOURCE
2	---	----	----------	----------
3	1	C1	capacitor 4.7uF 16vdc tantalum	J 94035
4	1	C2	capacitor 4.7uF 25v X7R ceramic 0.1"LS	D 445-8309-ND
5	3	C3-5	capacitor 0.1uF 50v X7R ceramic 0.1"LS	J 1570161
6	1	D1	LED display 7seg 7digit Rohm LS-2074M2G	P 19391-OP
7	2	D2,D3	1N4148 100v 0.3a diode small signal	J 179215
8	3	J2a,b,c	socket 10-pin Molex 22-18-2101	D WM3241-ND
9	*	J1,3	socket 2-pin (* cut from end of J2c)	
10	1	P1	header 6-pin 0.025"sq pins 0.1"LS	J 153700
11	3	Q1,2,3	NPN transistor w.22K/22K FJN3303R	D FJN3303RTACT-ND
12	2	Q4,5	PNP transistor w.22K/22K FJN4303R	D FJN4303RTACT-ND
13	3	R1,2,4	resistor 15K x 4 5-pin SIP bussed	D 4605X-101-153LF
14	1	R3	resistor 3.3K 5% 1/4w carbon film	J 690988
15	1	R5	resistor 100 x 3 6-pin SIP isolated	D 4606X-102-101LF
16	1	R6	resistor 100 x 4 8-pin SIP isolated	D 987-1253-ND
17	16	S0-F	pushbutton switch, tactile	D EG1832-ND
18	1	U1	74HC4040 12-bit binary counter	J 45920
19	1	U2	74HC393 dual 4-bit binary counter	J 251504
20	1	U3	74LS145 BCD-to-decimal decoder/driver	D 296-1641-5-ND
21	1	U4	74HC05 hex inverter, open collector	J 88081
22	1	U5	LED-darlington optocoupler, PS2502-1-A	D 559-1009-ND
23	1	Y2	piezo speaker 2KHz PUI Audio AB2720BLW	D 668-1405-ND
24	1	PCB	Z80 Membership Card Front Panel, rev.D	TMSI (me again)

Sources: B=bgmicro.com D=digikey.com E=goldmine-elec.com J=jameco.com P=mpja.com
Boards, parts, and complete kits available from TMSI c/o Lee Hart at <**www.sunrise-ev.com/z80.htm**>.

74LS

notch or dot end is Pin 1



74LS00	.39				
74LS01	.39				
74LS02	.39	74LS73	.65	74LS161	2.25
74LS03	.39	74LS74	.65	74LS163	2.25
74LS04	.45	74LS75	.79	74LS164	2.25
74LS05	.45	74LS76	.65	74LS181	3.69
74LS08	.39	74LS86	.65	74LS190	2.85
74LS10	.39	74LS90	1.25	74LS191	2.85
74LS13	.79	74LS92	1.25	74LS192	2.85
74LS14	2.19	74LS93	1.25	74LS193	2.85
74LS20	.39	74LS107	.65	74LS240	2.19
74LS26	.49	74LS112	.65	74LS245	2.25
74LS27	.45	74LS132	1.55	74LS257	1.89
74LS30	.39	74LS136	.65	74LS273	1.89
74LS32	.45	74LS138	1.89	74LS368	.99
74LS40	.49	74LS145	1.55	74LS373	2.85
74LS51	.39	74LS151	1.89	74LS393	2.79
74LS55	.39	74LS157	1.55	74LS670	3.95

MANY OTHERS AVAILABLE ON REQUEST
20% Discount for 100 Combined 7400's

CMOS

CD4000	.25			74C04N	.75
CD4001	.25			74C10N	.65
CD4002	.25	CD4035	1.85	74C20N	.65
CD4006	2.50	CD4040	2.45	74C30N	.65
CD4007	.25	CD4042	1.90	74C42N	2.15
CD4009	.59	CD4044	1.50	74C73N	1.50
CD4010	.59	CD4046	2.51	74C74	1.15
CD4011	.25	CD4047	2.75	74C90N	3.00
CD4012	.25	CD4049	.79	74C95N	2.00
CD4013	.47	CD4050	.79	74C107N	1.25
CD4016	.56	CD4051	2.95	74C151	2.90
CD4017	1.35	CD4053	2.95	74C154	4.00
CD4019	.55	CD4060	3.25	74C157	2.15
CD4020	1.49	CD4066	1.75	74C160	3.25
CD4022	1.25	CD4069	.45	74C161	3.25
CD4023	.25	CD4071	.45	74C163	3.00
CD4024	1.50	CD4081	.45	74C164	3.25
CD4025	.25	CD4511	2.50	74C173	2.60
CD4027	.69	CD4518	2.50	74C193	2.75
CD4028	1.65	74C00N	.39	74C195	2.75
CD4029	2.90	74C02N	.55	MC4044*	4.50
CD4030	.65			MC14016*	.56

LINEAR

LM309K	.99			LM709N	.29
LM324N	1.80			LM710N	.79
LM339N	1.25	LM380N	1.39	LM711N	.39
LM340T-5	1.75	NE555N	.45	LM723N	.55
LM340T-5	1.75	NE556N*	.75	LM741CN	.35
LM340T-6	1.75	NE561B*	5.00	LM1458C	.65
LM340T-12	1.75	NE562B*	5.00	LM3900N	.55
LM340T-15	1.75	NE566CN*	1.25	LM7805T	1.75
LM340T-24	1.75	NE567H*	1.95	LM78L05	.99

TRANSISTORS

Q1-5

2N2222A	5/$1.00			2N5088	4/$1.00
2N2907A	5/$1.00			2N5089	4/$1.00
2N3053	2/$1.00	2N4123	10/$1.00	2N5129	5/$1.00
2N3055	$ .69	2N4400	4/$1.00	2N5138	5/$1.00
MJE3055	$1.00	2N4401	4/$1.00	2N5139	5/$1.00
MJE2955	$1.25	2N4402	4/$1.00	2N5209	5/$1.00
2N3904	4/$1.00	2N4403	4/$1.00	2N5951	5/$1.00
2N3905	4/$1.00	2N4409	5/$1.00	C106B1SCR	2/$1.00
2N3906	4/$1.00	2N5086	4/$1.00	2N5432	$2.00

DIODES — ZENERS

D2

TYPE	VOLTS	AMPS	PRICE	TYPE	VOLTS	W	PRICE
1N4001	50 PIV	1 AMP	12/1.00	1N4734	5.6	1w	.28
1N4002	100 PIV	1 AMP	12/1.00	1N4736	6.8	1w	.28
1N4003	200 PIV	1 AMP	12/1.00	1N4738	8.2	1w	.28
1N4004	400 PIV	1 AMP	12/1.00	1N4742	12	1w	.28
1N4005*	600 PIV	1 AMP	10/1.00	1N4744	15	1w	.28
1N4006*	800 PIV	1 AMP	10/1.00	1N5232	5.6	500mw	.28
1N4007*	1000 PIV	1 AMP	10/1.00	1N5235	6.8	500mw	.28
1N4148	75	10mA	15/1.00	1N5236	7.5	500mw	.28

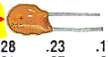
CAPACITOR CORNER

C3-6

50 VOLT CERAMIC DISC CAPACITORS

	1-9	10-49	50-100		1-9	10-49	50-100
10 pf	.05	.04	.03	.001μF	.05	.04	.035
22 pf	.05	.04	.03	.0047μF	.05	.04	.035
47 pf	.05	.04	.03	.01μF	.05	.04	.035
100 pf	.05	.04	.03	.022μF	.06	.05	.04
220 pf	.05	.04	.03	.047μF	.06	.05	.04
470 pf	.05	.04	.035	.1μF	.12	.09	.075

C1-3



+20% DIPPED (SOLID) TANTALUM CAPACITORS

1.0/35V	.28	.23	.17	4.7/25V	.32	.28	.23
3.3/25V	.31	.27	.22	10/25V	.40	.35	.29

Axial Lead

ALUMINUM ELECTROLYTIC CAPACITORS

Radial Lead

3.3/50V	.15	.13	.10	1.0/16V	.15	.13	.10
10/50V	.16	.14	.12	4.7/25V	.15	.13	.10
22/25V	.17	.15	.12	10/25V	.15	.13	.10
47/25V	.19	.17	.15	47/50V	.24	.21	.19
100/25V	.24	.20	.18	100/16V	.19	.15	.14
220/25V	.32	.28	.25	220/16V	.23	.17	.16
470/25V	.33	.29	.27	470/25V	.31	.28	.26
1000/16V	.55	.50	.45	220/16V	.23	.17	.16
2200/16V	.70	.62	.55	470/25V	.31	.28	.26

CONSUMER ELECTRONICS

PONG

SINGLE GAME $59.95

SUPER PONG

4 GAMES IN ONE $89.95

GAMES INCLUDED IN SUPER PONG ARE:

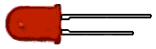
- PONG
- CATCH
- SUPER PONG
- HANDBALL

FEATURES OF PONG AND SUPER PONG

- Incremental speed on volleys increases excitement.
- Playing field adjusts to any size screen.
- Game appears in color or in black & white, depending on television set.
- Unmistakable "PONG" sound accompanies each volley.
- Digital scoring flashes on the screen between each point.
- 2 player challenge or Solitaire
- Hooks up simply to any model television set; the screen actually becomes the playing field.
- English and other techniques can be used to make any member of the family a Pong champion.
- Battery operated by 4 size "D" flashlight batteries included with the Unit.

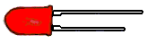
AC Adaptor (Eliminates Batteries) $9.95

SUPER SAVINGS! DISCRETE LEDS DISPLAY LEDS



.200" dia.

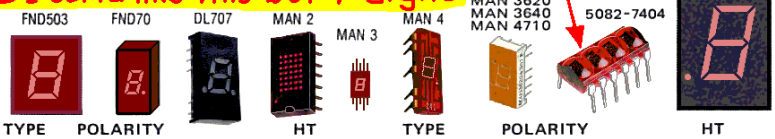
XC556Red	10/$1
XC556Green	7/$1
XC556Yellow	7/$1
XC556Orange	7/$1
XC556Clear	7/$1



.125" dia.

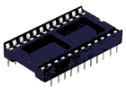
XC209Red	10/$1
XC209Green	4/$1
XC209Yellow	7/$1
XC209Orange	4/$1

D1 sorta like this but 7 digits



TYPE	POLARITY	HT		TYPE	POLARITY	HT	
MAN 2	5 x 7 Dot Matrix	.300	4.95	MAN 3640	Common Cathode-orange	.300	.99
MAN 3	Common Cathode	.125	3/1.	MAN 4710	Common Anode-Red	.400	.99
MAN 4	Common Cathode	.187	1.95	DL707	Common Anode	.300	1.50
MAN 7	Common Anode-red	.300	.99	DL 747	Common Anode	.600	2.25
MAN 7G	Common Anode-green	.300	1.95	5082-7404	Common Cathode	.110	.99
MAN 7Y	Common Anode-yellow	.300	1.95	FND70	Common Cathode	.250	.50
MAN 3620	Common Anode-orange	.300	.99	FND503	Common Cathode	.500	1.29

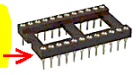
IC SOCKETS -- ECONOMY LOW PROFILE SOLDERTAIL (TIN)



	1-24	25-49	50-100		1-24	25-49	50-100
8 pin	$.17	.16	.15	20 pin	$.37	.36	.35
14 pin	.20	.19	.18	24 pin	.38	.37	.36
16 pin	.22	.21	.20	28 pin	.45	.44	.43
18 pin	.29	.28	.27	36 pin	.60	.59	.58
22 pin	.37	.36	.35	40 pin	.63	.62	.61

MACHINE TOOLED LOW PROFILE SOLDERTAIL (GOLD)

this kind →

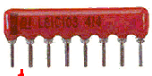


8 pin	$.45	.41	.37	20 pin	$1.05	.95	.85
14 pin	.39	.38	.37	24 pin	1.40	1.25	1.10
16 pin	.43	.42	.41	28 pin	1.59	1.45	1.30
18 pin	.75	.68	.62	40 pin	1.75	1.55	1.40

50 PCS. RESISTOR ASSORTMENTS $1.75 PER ASST.

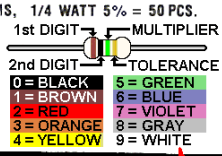
ASST. 1	5 ea.	10	12	15	18	22	27	33	39	47	56	OHMS,	1/4 WATT	5% =	50 PCS.
ASST. 2	5 ea.	68	82	100	120	150	180	220	270	330	390	OHMS,	1/4 WATT	5% =	50 PCS.
ASST. 3	5 ea.	470	560	680	820	1K	1.2K	1.5K	1.8K	2.2K	2.7K	OHMS,	1/4 WATT	5% =	50 PCS.
ASST. 4	5 ea.	3.3K	3.9K	4.7K	5.6K	6.8K	8.2K	10K	12K	15K	18K	OHMS,	1/4 WATT	5% =	50 PCS.
ASST. 5	5 ea.	22K	27K	33K	39K	47K	56K	68K	82K	100K	120K	OHMS,	1/4 WATT	5% =	50 PCS.
ASST. 6	5 ea.	150K	180K	220K	270K	330K	390K	470K	560K	680K	820K	OHMS,	1/4 WATT	5% =	50 PCS.
ASST. 7	5 ea.	1M	1.2M	1.5M	1.8M	2.2M	2.7M	3.3M	3.9M	4.7M	5.6M	OHMS,	1/4 WATT	5% =	50 PCS.

5 EACH MINIMUM PER VALUE ON ANY RESISTORS FROM 2.2 OHM TO 5.6M
5-25 PCS .05ea. 30-95 PCS .04ea. 100-495 PCS .03ea. 500-995 .0275ea.



SIP RESISTOR NETWORKS 125mW 5%
SPECIFY 6, 8, OR 10 PINS; ISOLATED OR BUSSED
100 220 470 1K 2.2K 4.7K 10K 100K OHMS

1-9	10-49	50-100
.29	.25	.19



Prices Good Thru Dec 1976. * Astrisk Denotes Specials This Month *
$5.00 Min. Order. U.S. Funds. California Residents — Add 6% Sales Tax
Send a 13c Stamp (postage) for a FREE 1976 Catalog — Data Sheets 25c each

SIP R's

R1, R2, R3

C2

Jameco ELECTRONICS

1021 HOWARD AVE, SAN CARLOS, CA 94070
PHONE ORDERS — (415) 592-8097

SUBJECT: Assembly Notes
DATE: 27 Jan 1980
FROM: chip8080 [71323,0142]
TO: wizwireman [72404,1991]

Hah. Be nice, or I'll tell Gil what you're REALLY doing on vacation!

No, I don't have a proper "Heathkit" assembly manual yet. The boards we built here are kind of learn-as-we-go things, so I could check out the hardware, and Crash could debug the software. We still need to work out the best way to assemble it.

Tracey did a fantastic job on the layout! You got rev.C boards -- be glad you didn't get the rev.A boards. Here are some "goodies" and "gotchas" that may help:

Thinking "Inside the Box":

1. If you want a two-board stack to fit in an Altoids box with the LID CLOSED, it takes some extra effort to get the boards very close together:

   a. Cut the leads on the back sides of the boards VERY SHORT. Otherwise, they will short to the metal Altoids case or between boards.

   b. Normal IC sockets are too tall. I sent ultra-low-profile sockets for the Z80 and memory chips. To socket everything, get more at digikey.com (ED53##-ND, where ## is the number of pins), or use socket pins (digikey.com ED5037-ND).

   c. REMOVE the plastic body of the 30-pin headers to get the boards closer together. There are instructions for how to do this in the assembly instructions on page 15.

2. If you DON'T CARE about putting it in an Altoids box, or are willing to remove the top cover of the box, assembly is much easier. Just solder the headers on top of the CPU board as usual. The boards wind up spaced 0.1" farther apart. That gives you enough room to use ordinary IC sockets, too.

Male? Female? Keying?

I put male pins on TOP of the CPU board, and female sockets on the BOTTOM of the Front Panel board. It's easier to get female connectors that accept individual wires, or ones that mount on other boards (like the Front Panel). Additional boards have female sockets on the bottom and male pins on top, so they all stack together.

But there is no keying! Watch out for this. I put a wide stripe on the "P2" edge of each card as a visual cue. Or, you could put sockets on the top, and pins on the bottom at one or more locations (such as the center 10 pins of P1). That will prevent plugging cards in backwards. If you have any better ideas, let me know.

Stand-alone Option:

The instructions describe the "standard" setup with a Front Panel card. You'll install 5v regulator U8. The 2-card stack is powered from P4 on the Front Panel.

Optionally, you can use the CPU card alone, as a single-board computer. For this, do not install U8. Short U8 pin 1 to pin 3. Install a 6-pin header at P4 (with pin 2 removed as a key). It has the same power and serial I/O pins as P1 on the Front Panel, so the same Sparkfun.com FTDI USB-serial cable #9718 works for both. Also, short P3 (right next to P4) to connect /INT to IN7 (the serial input).

-- Chip

Z80 Membership Card - Assembly Details

Here's a Polaroid of the board, with comments on assembling it. All parts go on top, and are soldered on the bottom. Cut off the excess lead length on the bottom as short as possible, so they won't short to the Altoids case! When you finish installing each part, **circle** the designator (U7, C6 etc.) so you know it's done.

Watch out for the polarity of the ICs, C1, C2, and the SIP resistors. The part numbers printed on the ICs should be right side up in this view.

U7 74HC245. Pin 1 goes on the left. The end with the notch or dot marks pin 1 --> /////////

R5 2.2K 6-pin SIP. black, marked 6B222G. pin 1 left->||||||

Note: C1 and C2 +/- point in opposite directions!

C5 0.1uF yellow, marked 104

C2 33uF black, + - in top hole (toward P2)

C1 4.7uF yellow, + - in top hole (toward P2)

C6 0.1uF yellow, marked 104, and 0.2" wide

P2 30-pin header Install it as described for P1 (below).

U6 74HC273. Pin 1 on left end.

U8 L4941BV. Face metal tab **UP** (AWAY from the board). Add a #2 screw & nut if desired.

U4 74HC368. Pin 1 on left end.

Y1 4MHz resonator orange, 3 pins |||

U3 socket first, then EPROM IC. Pin 1 on left. Push hard!

R1 1meg --|-- brn-blk-grn-gold

U1 Z80. Solder socket 1st, then plug in Z80. The socket is TIGHT, so push hard!

U2 socket first, then RAM IC. Pin 1 on left. Push hard!

C3 0.1uF yellow marked 104

P1 30-pin header:

1. Push pins into body. ==[]== --> []===

R2 1meg --|-- brn-blk-grn-gold

2. Put on board with body on bottom so pin []=== is 1/4" (6.35mm) high

C4 0.1uF yellow, marked 104

R3 2.2k 10-pin SIP red, pin 1-->||||||||||| marked 103S222 Pin 1 at left end.

U5 74HC138 Pin 1 at left end

R4 2.2k 8-pin SIP black, pin 1-->||||||||| marked L81S222. Pin 1 at left end.

3. Solder on top.

4. Cut off body and excess pin length on the bottom. ===

Hint for P1 and P2: If your solder joints look "ugly", push one of the mating female connectors for J1 (in the bag of parts for the Front Panel) on the TOP of the pins to hold them in place. Then re-solder the pins again from the BOTTOM side to make the joints look "pretty". Remove the female connectors when done.

Z80 Front Panel Card – Assembly Details

Here's a Polaroid of the Front Panel board, with a few more "hints and kinks". All parts go on top, EXCEPT the female sockets at J1, J2, and J3. As usual, watch out for +/- polarity and pin 1's. **Circle** the designators as you install each part.

Serial I/O: There are **TWO** ways to assemble it. Do **ONE** of the following (a or b):

a. Real RS-232 serial I/O, with idle = -5v to -12v, active = +5v to +12v:
   Install Q1, Q4, D2, R3, and C2.

b. TTL serial I/O, with idle = +3v to +5v, active = 0v (i.e. USB-serial adapters):
   Install scrap pieces of wire as **shorting jumpers** in place of Q1 and Q4.

Transistors Q1-Q5: Install P1, D1, and switches **FIRST**. Then install transistors qu with flat side as shown on the board. Get them as close to the board as possible (no higher than the switches, P1 or D1).

Q1-Q5

Emitter | Base
Collector

C5 0.1uF marked 104

C1 4.7uF yellow, + wire in hole toward S1. Lay it **FLAT**.

C3 0.1uF marked 104

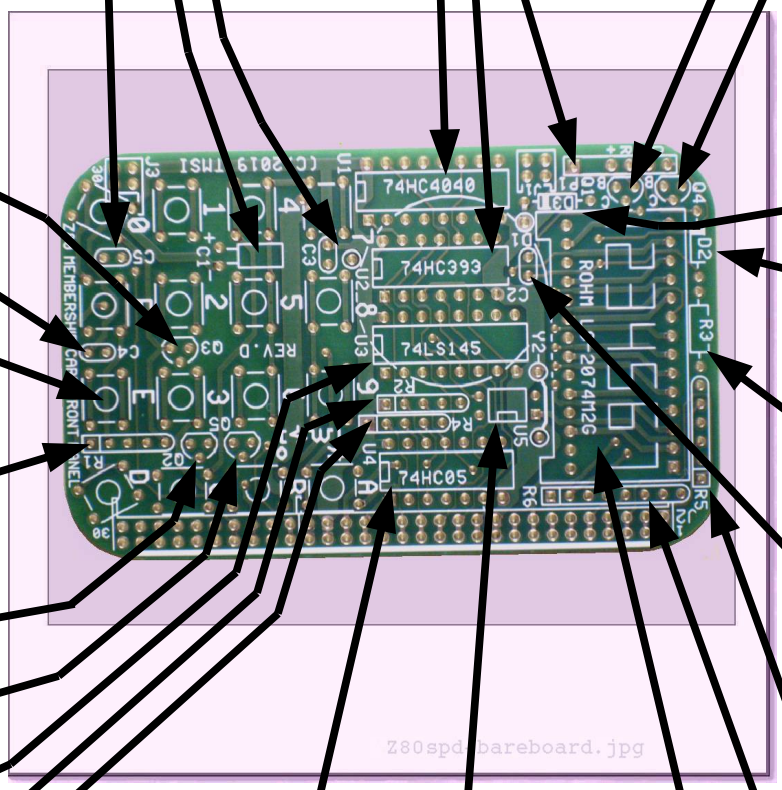
U1 74HC4040 pin 1 on left

U2 74HC393. pin 1 left

P1 6-pin header. Remove pin 2

Q1: Serial input:
a. For RS-232: Q1 = **FJN3303R.** marked R3303
b. TTL: **no** Q1; install jumper (O) wire at Q1.

Q4: Serial output:
a. For RS-232: Q4 = **FJN4303R.** marked R4303
b. TTL: **no** Q4; install jumper (O) wire at Q4.



Q3 FJN3303R marked R3303

C4 0.1uF marked 104

S0-SF Pushbutton 16 switches in 16 places

R1 15K 5-pin SIP red, marked L51S153

Q2 FJN3303R marked R3303

Q5 FJN4303R marked R4303

U3 74LS145 pin 1 left

R2 15K 5-pin SIP red, marked L51S153. Pin 1 left

R4 15K 5-pin SIP red, marked L51S153

U4 74HC05. pin 1 left

U5 Optocoupler marked 2502, dot for pin 1 in lower right corner.

D1 LED display. Trim its "toenails" so it sits level

D3 1N4148 diode. Band end left

D2 1N4148 diode. Band end up
a. RS-232: add D2
b. TTL: **no** D2

R3 3.3K-- org-org-red-gold
a. RS-232: add R3
b. TTL: **no** R3

C2 4.7uF marked 475
a. RS-232: add C2
b. TTL: **no** C2

R5 100 6-pin SIP black, marked L63S101. Pin 1 bottom.

R6 100 8-pin SIP black, marked L83S101. Pin 1 on left.

Z80 Front Panel Card - Assembly Details (continued)

J1, J2, and J3 -- We actually need one 24-pin socket (J2), and two 2-pin sockets (J1 and J3). All I could get were 10-pin parts. You need to cut one of the 10-pin connectors to make a 4-pin, and two 2-pin connectors. Use the 4-pin piece and two of the 10-pin parts to make the 24-pin socket. Here's how to cut it:

1. Lay the socket on the table with the pins pointing away from you, and the two "ears" at the ends pointing up. There is a tiny "1" at the right end, and a tiny "10" at the left end. These are the pin numbers.

```
                    6  3     <--pins to remove
pin 10-->  |||||||||||      <--pin 1
           |           |    <--body of socket
           |||||||||||||    <--slots that hold the pins in
 "ear"-->  |           |    <--"ear"
```

2. Use a small screwdriver to push down the tab inside the slots of pins 3 and 6. Now pull pins 3 and 6 out of the body.
3. Using a sharp knife or hacksaw, CUT the socket in the middle of pin positions 3 and 6. This gives you a 4-pin, and two 2-pin sockets with ragged cut ends.
4. Trim and smooth the cut ends to satisfy your artistic sense. (They won't get in the way; they just look ugly.) You can use a knife, sandpaper, file, etc.
5. Cut off the "ears". (They get in the way of other parts.)

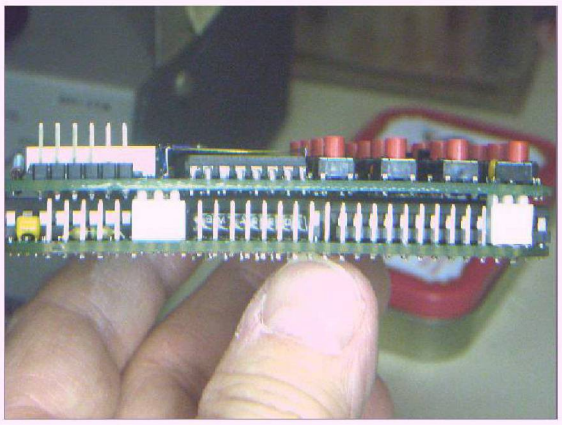
Install these female sockets on the **BOTTOM** (soldered side) of the board. There are pairs of holes for each one. Solder the pins of the socket into the **INNER** row of holes that are **AWAY** from the edge of the board.

Like this...

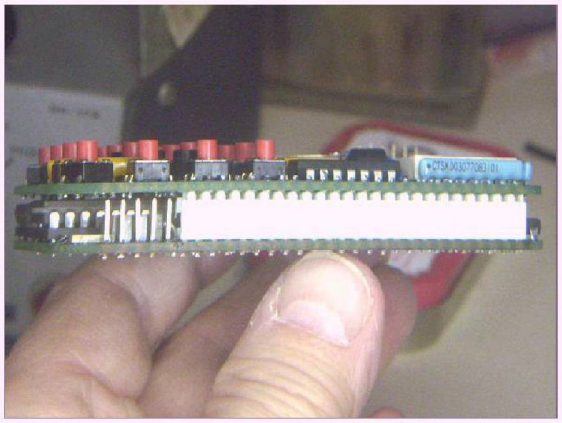
```
edge of PC board
                 ____
  hole o|   o| hole
 pin ==o|____|
          /|  "ear"
       / \
top of   bottom
board    of board
```

J1 2-pin socket: Install it on the BOTTOM, solder it on top.
J3 2-pin socket: Install it the same as J1. (J1 and J3 are just used as spacers to hold the two boards apart).
J2 24-pin socket: Install a 10-pin socket at pins 1-10 (in the lower right corner of the photo on page 16). Install a 2nd 10-pin socket next to it at pins 11-20. Install the 4-pin socket piece next at pins 21-24.

Plug the cards together as shown below (P1 to J1, P2 to J2). Check to be sure none of the exposed Z80 card pins short to anything on the bottom of the Front Panel!



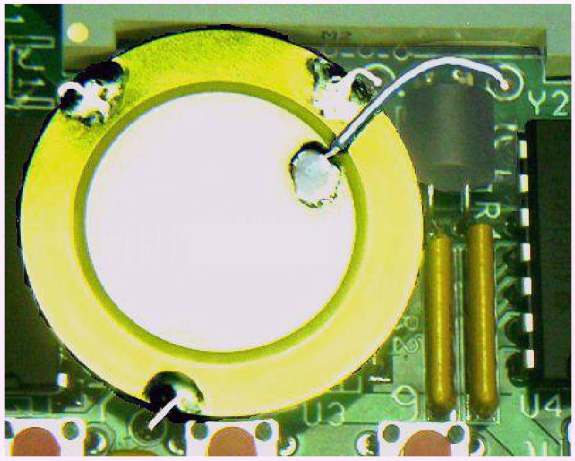
P1-J1 side, cards plugged together.
No plastic body on CPU card pins.
2-pin sockets on Front Panel bottom.



P2-J2 side, cards plugged together.
Sockets on bottom of Front Panel.
No sockets on left six pins.

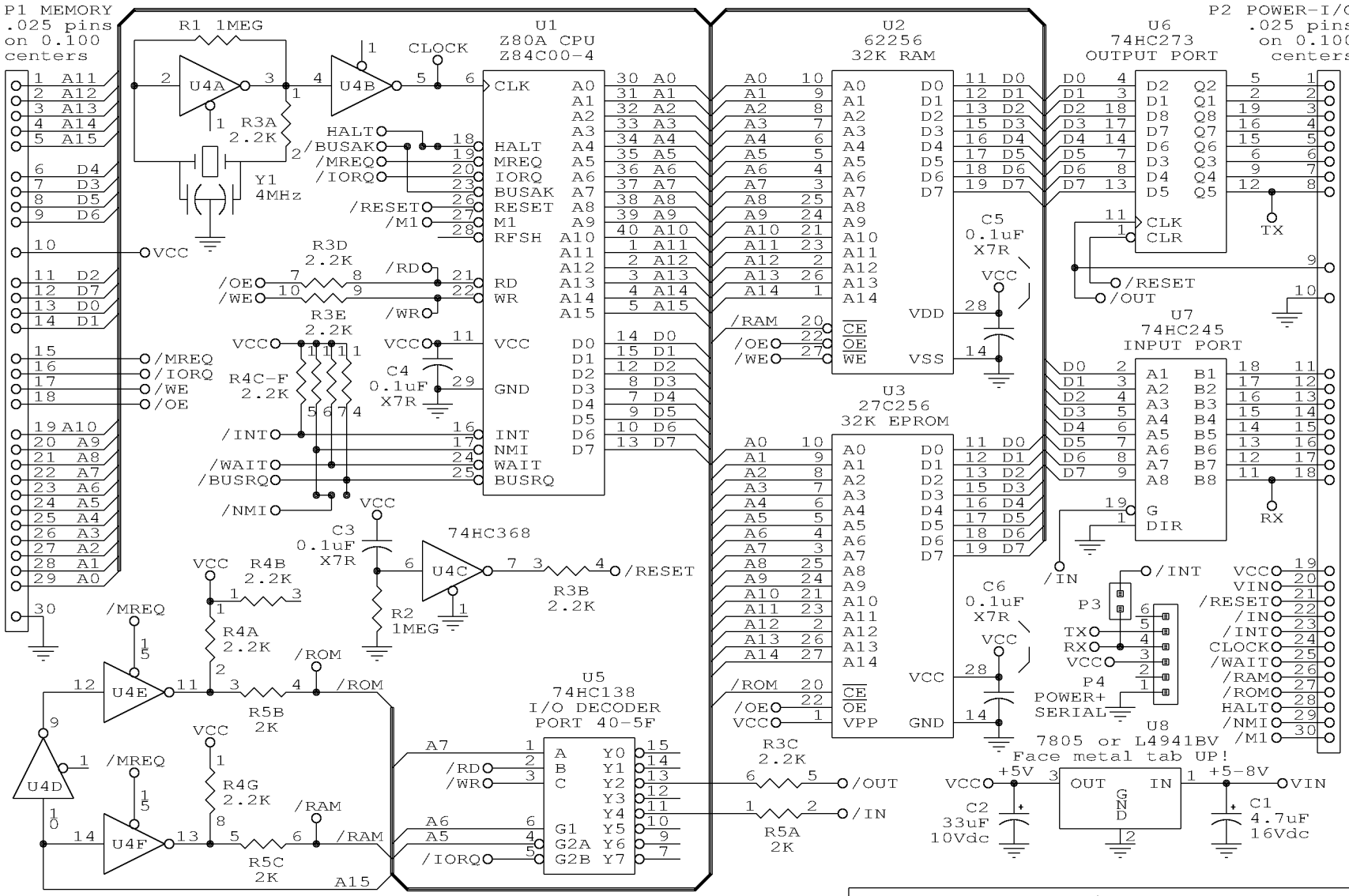
Y2 Piezoelectric Speaker -- This is a brass disk about 1" in diameter. It sits on top of U2 and U3, so install it after everything else is on the board.

1. Solder a 1/2" (12mm) piece of scrap wire in each of the 3 holes that outline the disk.
2. Lay a strip of paper between the wires to space the disk up so it won't touch U2-U3. (If it touches, it dampens the sound.)
3. Lay the disk on top, silver side up. Put the wire in the hole marked "Y2".
4. Bend the other 3 wires to touch the edges of the disk, and solder them to the edges. Cut off any excess wire length.
5. Remove the paper. There should be a small air space between the disk and U2-U3.
6. Finally, solder the last wire from the top of the disk into the hole labeled "Y2".



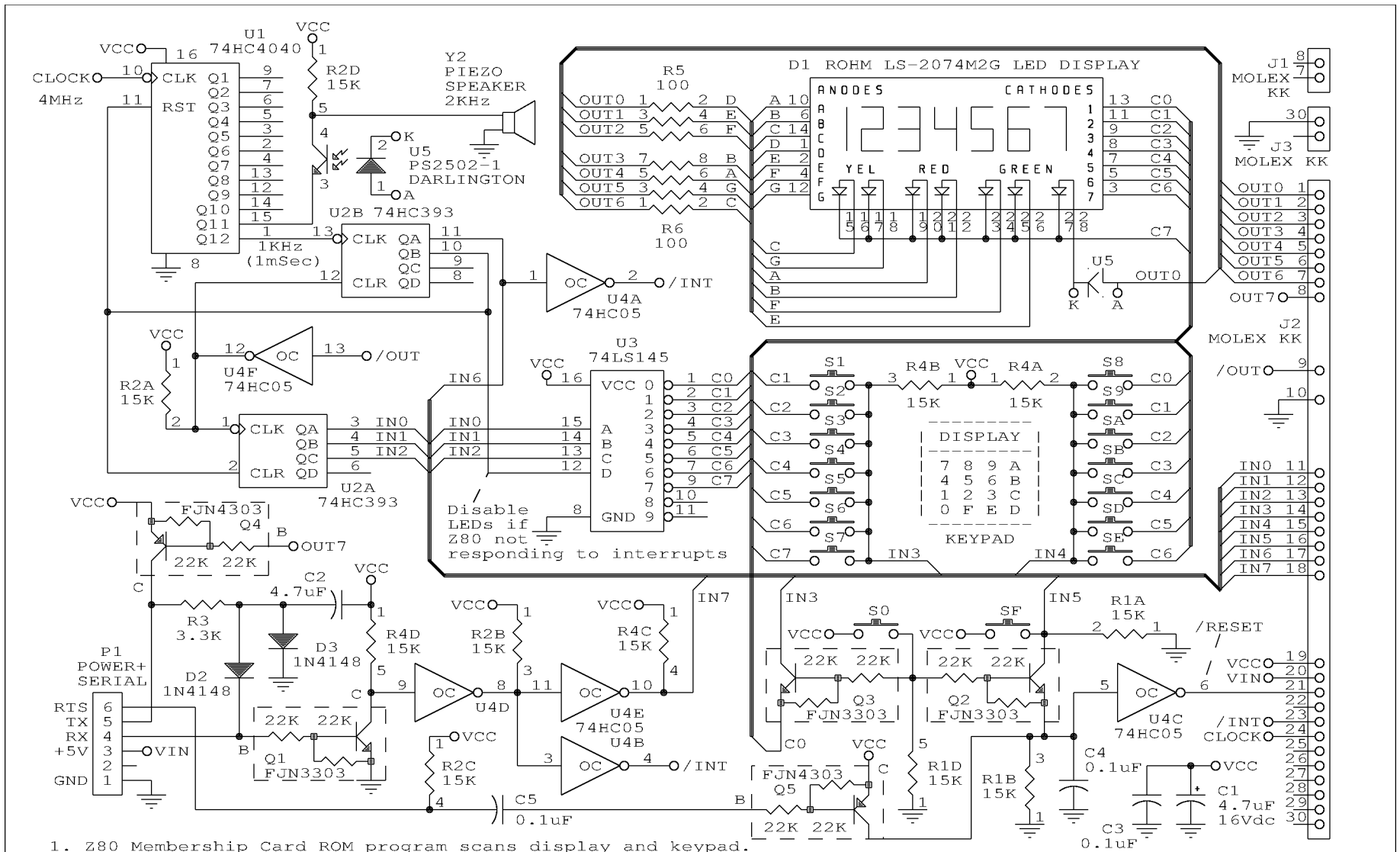
Piezo Speaker Y2 on Front Panel

That's it -- You're done! To see if it works, read the "Crash Course in Computing" for quick-start operating instructions. Then download the current version of the complete "Operating Manual" at http://www.sunrise-ev.com/photos/z80/Z80MC-2017.pdf



Notes:
1. All ICs powered by VCC. Uses C1-6, P1-3, R1-5, U1-8, Y1.
2. ROM at 0-32k, RAM at 32-64k. /RAM, /ROM, /IN, and /OUT can be externally forced high or low to change memory and I/O maps.
3. Rev.B: Add P4 power+serial connector. Install P4 for stand-alone use, or install U8 on-board regulator to use with daughterboards. Added jumpers for P2-29 = NMI or BUSRQ, P2-28 = HALT or BUSAK.

TMSI c/o Lee Hart		
Title: Z80 Membership Card		
Size: A	Document Number: C:\ORCAD\SHEET\Z80\Z80-MCB.SCH	REV: B
Date: February 16, 2019	Sheet 1 of 1	



1. Z80 Membership Card ROM program scans display and keypad.
2. ICs powered by VCC. Uses C1-5, D1-3, P1, J1-4, Q1-5, R1-6, U1-5.
3. RESET if P1 pin 4 (RTS) low, or F and 0 keys pressed at same time.
4. IN0-2 is key=0-E. IN3=0 if key=0-7. IN4=0 if key=8-E.
   IN5=1 if key=F. Can also use F key as Shift with 0-E keys.
5. If 1msec clock, IN6=1 and /INT=0. If RX active, IN7=0 and /INT=0.
6. Rev.A: J1 renamed to P1, P2 renamed to J1.
7. Rev.B: U4 74LS01 now 74HC05. P1 5- now 6-pin. Add C4,C5, SIP R1,R2.
8. RX, TX, RTS are BASIC Stamp2 type bit-banger serial port.
   a. For RS-232 (normal; active high): Install Q1,Q4,C2,D2, and R3.
   b. For TTL (active low): Leave 8a parts off, short Q1 B-C, Q4 B-C.
9. Rev.C: Add D3 (prevents /INT if serial input not connected to P1).
10. Rev.D: U5 was opto-resistor, now opto-darlington.

TMSI c/o Lee Hart

814 8th Ave N
Sartell MN 56377

Title
Z80-MC Front Panel, U5 = transistor opto

Size	Document Number	REV
A	C:\ORCAD\SHEET\1802\Z80-SPD.SCH	D

Date: May 2, 2019 | Sheet 1 of 1

Z80 Machine Code Quick Reference

(C)1976 by Mary Bell

Codes 00-3F

1 \ 16	0	1	2	3
0 JR	NOP	DJNZ	NZ	NC
1 nn→	BC	DE	HL	SP
2 A→	(BC)	(DE)	HL→(nn)	(nn)
3 INC	BC	DE	HL	SP
4 INC	B	D	H	(HL)
5 DEC	B	D	H	(HL)
6 n→	B	D	H	(HL)
7	RLCA	RLA	DAA	SCF
8 JR	AF↔AF'	unc	Z	C
9 HL+	BC	DE	HL	SP
A →A	(BC)	(DE)	(nn)→HL	(nn)
B DEC	BC	DE	HL	SP
C INC	C	E	L	A
D DEC	C	E	L	A
E n→	C	E	L	A
F	RRCA	RRA	CPL	CCF
1 / 16	0	1	2	3

Codes C0-FF

1 \ 16	C	D	E	F
0 RTN	NZ	NC	PO	NM
1 POP	BC	DE	HL	AF
2 JMP (nn)	NZ	NC	PO	NM
3	JMP UNC	OUT (n)	↔HL (nn)	DIS INT
4 CALL (nn)	NZ	NC	PO	NM
5 PUSH	BC	DE	HL	AF
6 A/n	+	-	AND	OR
7 RST	00h	10h	20h	30h
8 RTN	Z	C	PE	M
9	RTN	EXX	JMP (HL)	HL→SP
A	Z	C	PE	M
B	CNTL BITS	IN (n)	↔HL ↔DE	ENA INT
C CALL (nn)	Z	C	PE	M
D	CALL UNC	IX for HL	EXT INS	IY for HL
E A/n	+/c	-/c	XOR	CPI
F RST	08h	18h	28h	38h
1 / 16	C	D	E	F

ED Extended Instructions

1 \ 16	4	5	6	7	A	B
0 IN (c)→	B	D	H		LDI	LDIR
1 OUT →(c)	B	D	H		CPI	CPIR
2 HL-/c	BC	DE	HL	SP	INI	INIR
3 →(nn)	BC	DE		SP	OUTI	OUTIR
4	NEG					
5	RET NMI					
6	IM0	IM1				
7	A→I	I→A	RRD			
8 IN (c)→	C	E	L	A	LDD	LDDR
9 OUT →(c)	C	E	L	A		
A HL+ /c	BC	DE	HL	SP	IND	INDR
B (nn)→	BC	DE		SP	OUTD	OUTDR
C						
D	RET MI					
E		IM2				
F	A→R	R→A	RLD			
1 / 16						

Codes 40-7F (Moves & Ops)

Operations w/A

+/c	-/c	XOR	CP
+	-	AND	OR
8	9	A	B

16's

Destination

C	E	L	A
B	D	H	(HL)
4	5	6	7

Source Register

B	C	D	E	H	L	(HL)	A
8	9	A	B	C	D	E	F
0	1	2	3	4	5	6	7

1's

76=HALT

Flags

S	Z	--	H	--	P/V	N	C

CB Group Instructions

Register

B	C	D	E	H	L	(HL)	A
8	9	A	B	C	D	E	F
0	1	2	3	4	5	6	7

1's

Bit #

	1	3	5	7
Set	C	D	E	F
Reset	8	9	A	B
Test	4	5	6	7

16's

Shifts

RRC	RR	SRA	SRL
RLC	RL	SLA	
0	1	2	3

RLC

RRC

RL

RR

SLA ←0

SRL 0→

SRA

RLD Acc (HL)

RRD

The Z80 instruction set is powerful, but complex. Any attempt to summarize it is bound to be confusing. Here are two examples on how to interpret the above Quick Reference:

-INC HL (increment register pair HL) is in the top left chart. INC=x3, and HL=2x; so the opcode is 23.
-ADD C is a math operation, so see the "Moves & Ops" chart. ADD=8x, and C=x1; so the opcode is 81.

The Cast

Chip Hacker

The hardware designer. He starts with a Mark-8, then switches to an Altair 8800, and keeps upgrading it until there's nothing original left of it. Gets tired of all the problems, and buys a Heathkit H8.

When the Z80 comes out, he recognizes it as superior to the 8080, and builds a CPU board with it. Adds memory, then parallel and serial I/O. Then a keypad and LEDs to make a front panel like the H8. It winds up a single-board computer that evolves into the Z80 Membership Card.

Gil Bates

The "idea" man and marketing manager. Always looking ahead for "the next new thing". He realizes that:

1. Computers are a BIG DEAL that will change the world.
2. The change is happening fast. You can't succeed by copying what other people are doing, or looking just one step ahead.
3. Computers come in big beige boxes. People prefer SMALL packages (calculator-sized) that they can take anywhere.
4. Sees that microcomputers need lots of "hacking" to make them work, but how successful Apple is selling "computers for the rest of us".
5. Sees that people are insanely focused on CHEAP, but traditional computers are expensive.
6. So he's out to make something Small, Easy to use, and Cheap, but that's ahead of what everyone else is doing.

Tracy (Trace) Weaver

She enters the picture when they need to get PCBs laid out. She works at a firm where she can "borrow" CAD time to do it. Can layout boards that pack the parts much tighter than is normally done at the time (smaller, lower cost).

Willard (Wiz) Wireman

He enters as a tech. Can build things faster than Chip, so things get done quickly. But he has poor attention to detail (thus the inclusion of assembly instructions).

Richie (Crash) Kernigan

Software genius. Writes the software. The name is a play on C creators Dennis Ritchie and Brian Kernighan. I mis-spelled it on purpose. If it's still too close for comfort, I figure I can use "Crash Runagain".

Changes

Z80 CPU board, rev.A:
    R3 was 2k, now 2.2k
    C1 was 3.3uF, now 4.7uF
Front Panel board, rev.B:
    U4 was 74LS01, now 74HC05
Front Panel board, rev.C:
    added D3 (stops TXD from affecting RXD if nothing is connected to RXD)
Jul 30, 2017: changed EPROM program from ZMCv1.1 to ZMCv1.5
Dec 31, 2017: Front Panel R1,2,4 was 10k, now 15k.
Apr 15, 2019: Z80 CPU board, rev.B: Inverted U8 (metal tab up). Added P3 and P4 to support stand-alone operation. Added jumper options for /BUSRQ, /BUSAK.