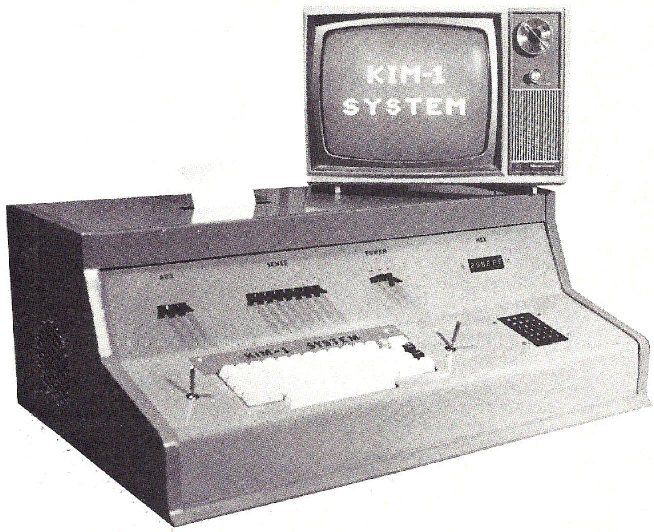

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Photo 1. The KIM-1 System.

Photos by Thomas Snider

Expand Your KIM!

. . . with Altair bus devices

If you're lucky enough to be a KIM owner, or plan to be, this is the first in a series of articles that will show you one approach to expanding your one-board computer into a full-blown, unbelievably versatile, reasonably priced system.

If you have already spent your money on a 6800, do not despair. The information will be in a general format so that it can be applied to other processors.

You'll learn, for example, how to interface Altair bus peripherals, such as memory or a TV Dazzler, to a general bus.

A Southwest Tech keyboard and 40-column printer will become a miniature Teletype.

A software driver for the Dazzler will turn it into a television typewriter with up to ten 32-character lines that are readable at classroom distances. Since a class can read the output, I will later discuss some educational software.

My articles will not be just schematics and program listings. Being a professor of computer technology, I hope to generate some thought on your part. I will tell you how,

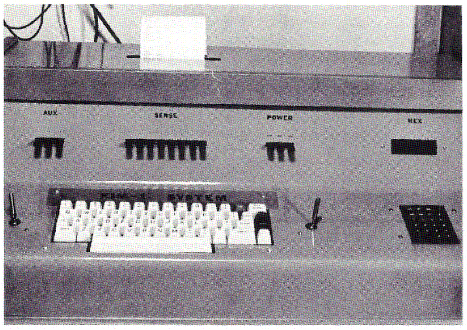

Photo 2. The front panel includes everything from sense switches to joysticks.

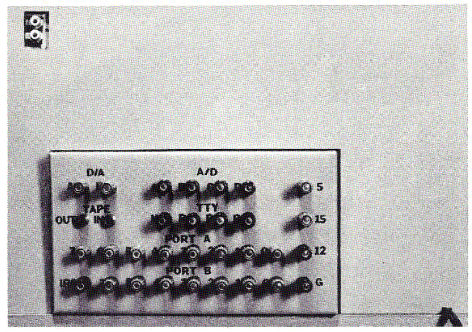

Photo 3. A backplane of banana jacks provides easy interfacing for experimenters.

but I'll emphasize why and even why not.

I will assume that you have a general knowledge of digital electronics. If you feel lacking in this area and you wish to build a KIM-1 System, I suggest you study the previous "Kilobaud Klassroom" articles by George Young.

If you want to really understand your system, you will appreciate my approach. If you want a step-by-step, solder-this-wire-here format, do yourself a favor and stick to kits and canned programs.

Most computer hobbyists do just that. They purchase a general kit consisting of a CPU board, power supply, limited memory, and a front panel. Once they get it up and running, some form of I/O device such as a video terminal usually is next on their list. After discovering how long it takes to reload their favorite program, they soon acquire a cassette interface. I've found that these units are what most hobbyists consider a "complete" system. The newest kits on the market are evidence of this, as they offer all the above in a single package, and perhaps on a single board. The cost of such a system will very depending on which manufacturer you choose, but in most cases a complete system as described above will cost between $1000 and $2000.

I have wanted a personal computer for a long time and therefore have had a chance to develop a large variety of uses and reasons for owning one. Since I am a teacher, I wanted to learn as I built my system, so that the knowledge of microprocessors would not pass me by. I also wanted to be able to demonstrate various hardware and software concepts in the classroom. Naturally, the enjoyment of programming my own games and perhaps even using the system for practical things like averaging grades or as a real-time visual aid was also a priority.

To be effective then, my system would have to be much more than just complete. In addition to the parts previously mentioned, I wanted a hard copy output, A/D and D/A converters, joysticks, color graphics and some convenient means of temporarily connecting any of the capabilities to external equipment, in case the urge to experiment hit me.

Not only did I want all of the above, but I required it to be contained in one portable enclosure, at a total cost of less than $1500. As impossible as it sounds, I have built such a system, with even more capabilities than I had hoped, for $1300.

Fig. 1 shows the basic block diagram. The heart of the system is the KIM-1. Since many articles have been written on it, I'll not bore you with a rehash of its capabilities. A *bus control* board generates the necessary signals to interface KIM to a modified Altair bus. I have no intention of claiming that every 8080 peripheral made will operate on this bus, but you should have no trouble with many boards.

A 4K memory board has been modified to operate in K1 through K4 using the KIM on board decoding, thus providing the proper memory locations for Tiny BASIC

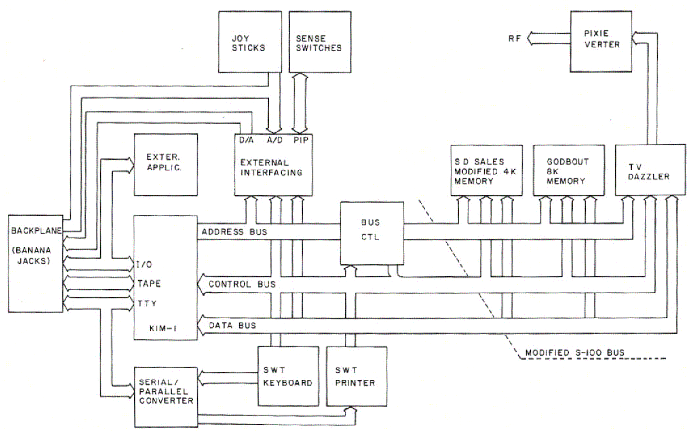

Fig. 1. A block diagram shows the completeness of the KIM-1 System.

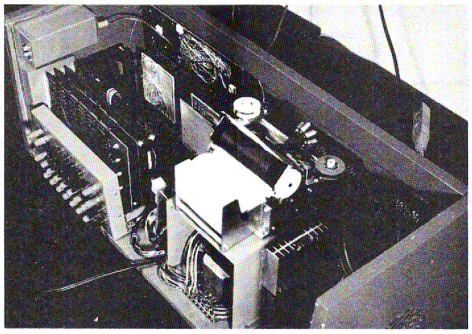

Photo 4. The top and back panels are easily removed for access.

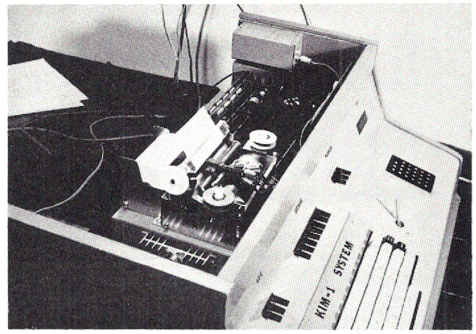

Photo 5. Hard copy is provided by a 40-column impact printer.

with a little extra space for user subroutines and the TVT driver.

The 8K memory board uses the first 2K as display memory for the Dazzler, and the remaining 6K for user programs. Of course, the entire 13K (K0 is on the KIM-1) is available for user programs if assembly language is used.

The *serial/parallel converter* board converts the SWTPC keyboard and printer into a miniature Teletype. Since the printer dumps a line at a time, true TTY operation is not possible, but the TVT driver mentioned earlier will greatly lessen most of the disadvantages.

The *external interfacing* board provides an input port for the sense switches and the A/D and D/A circuits. This board is based on the assumption that the hobbyist doesn't need 100 percent accuracy if he can approach it for a fraction of the cost. It does provide true A/D (the input is a voltage not a resistance), which makes it much more versatile for experimental applications.

And, speaking of experimental applications, a backplane is provided to allow the system's capabilities to be easily connected to temporary circuits for demonstrations and prototypes.

Although the KIM nondedicated I/O ports are wired to the backplane for experimenting, they also connect to a 44-pin edge connector to allow more permanent applications. One application example is a super simple ($20) 30-function calculator interface as described in an issue of *KIM User Notes*.

Photo 1 shows the cabinet, which is 30 inches long and is completely self-contained. An RF modulator is built in so that any television may be used for the video display. I named the system KIM-1, after its CPU board.

A closeup of the front panel is shown in Photo 2. Both ASCII and hex keyboards are provided and are under ROM control. The hex keyboard also provides troubleshooting aids, such as single step and internal register interrogation.

In the upper right corner is a six-digit seven-segment display. Under ROM control the display is in hexadecimal, but can be programmed on a segment-by-segment basis, providing nearly unlimited uses.

The toggle switches are grouped as auxiliary (general purpose), power (self-explanatory), and sense. The sense switches, being connected to an input port, provide an easy means of interfacing with the software.

The joysticks are permanently mounted on either side of the ASCII keyboard. Their digital outputs are read by the processor as normal memory locations.

Photo 3 shows a closeup of the back panel. Two nondedicated I/O ports, interrupt, A/D, D/A and tape recorder outputs are readily available. Four jacks even provide 20 mA loop signals so that a TTY can replace the internal printer and keyboard. The RF and video outputs for the television can be seen in the upper left hand corner of the panel.

The back and top of the cabinet (Photos 4, 5, 6) are easily removed, and provide access for assembly and troubleshooting.

Hard copy is provided by the 40-column impact printer. It mounts on a steel frame that acts as a magnetic shield for the power supply transformers.

One end of the cabinet is empty and can be used for future expansion, such as the permanent mounting of a tape drive.

The entire mainframe is removable (Photo 7), and consists of six 44-pin and four 100-pin connectors. All major circuits of the computer proper are mounted on this frame.

In order to keep the cost to a minimum, I explored the many products available, looking for those that offered the maximum return for the dollars invested.

Table 1 summarizes the chosen products and lists the approximate costs for each. Each product was carefully analyzed and, at least in my

KIM-1 MOS Technology	$245
Dazzler Cromemco	215
Memory-4K SD Sales	90
Memory-8K Godbout	165
Printer (40-column) SWT PC	250
Keyboard SWT PC	50
Other miscellaneous components	285
TOTAL	$1300

Table 1. The 13K KIM-1 System, complete with joysticks, hard copy and color graphics costs only $1300.

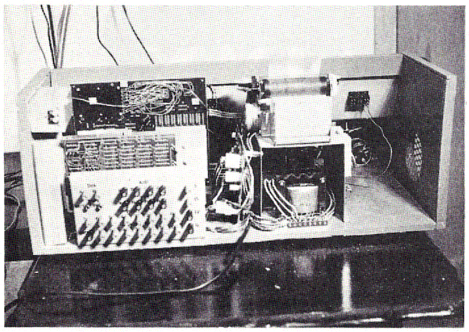

Photo 6. One end of the cabinet is empty and can be used for future expansion.

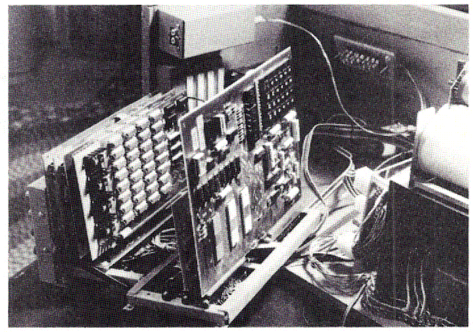

Photo 7. The entire mainframe can be removed for troubleshooting.

opinion, individually provides more for your money than most products on the market. Table 2 lists some of the miscellaneous parts so that those interested in building the system can begin collecting the hardware.

I guess *individually* was the key word in the last paragraph, because none of these units were meant to be used together. After many weeks of studying schematics, buses, etc., I developed several simple but effective circuits that would enable all the units to operate together as a system.

And it is a system I call complete. I have both hard copy and video text. The fifteen colors of graphics have three levels of software-controlled resolution. The joysticks, with their two-dimensional movement, provide more realistic participation in video games. The ASCII and hex keyboards provide a versatility I've come to appreciate. The cassette interface operates without failure and can load all 13K of memory in under five minutes.

If you like experimenting, the backplane of banana jacks is a dream come true. Although the cabinet is not small, it is far more portable than most other systems with similar characteristics.

I considered a ROM board, but have rejected it. A full discussion of this decision will come at a later date. For those with conflicting philosophies, a piggy-backing of the dazzler boards will free up one Altair slot for ROM or perhaps a 16K RAM.

The empty end of my cabinet can hold a small disk, but I'm waiting to see how bubble memories turn out. Their application as a "solid state" disk intrigues me very much.

One advantage that you will have over most hobbyists is that if you build this system you will understand it. My detailed studies of each unit have shown me their capabilities and their weaknesses, and I hope to include as much of this knowledge as possible in my articles. I have concluded this is a system I won't soon become bored with, and I look forward to many happy hours watching my programs come to life as they control the many I/O peripherals.

I'm already dreaming up unusual displays, demonstrations and games that will push the system and my programming abilities to their limits, and that's what having a hobby computer is all about.

I've spent a lot of time developing my system to the point where I believe it provides more than any other hobbyist system at any cost. less of cost.

Next month I will provide the information on the construction and wiring of the mainframe, power supply and cabinet.

The articles then will get more educational as the bus control, serial/parallel and external interfacing boards are discussed separately and in great detail.

After that, I will turn to software. Each program will be selected in part to insure that builders of the KIM-1 system can fully utilize each of the peripherals.

In keeping with my desire to maintain a general tone, the software articles will be heavy on organization and strategy, and I hope, will be useful to many non-6502 owners.

I'm convinced that the 6502 is going to become the most popular hobbyist processor. As you read my future articles, I think you'll see why. ■

14	DPDT toggle switches.
2	100K joysticks.
2	6.3 V 10 Amp CT transformers.
2	15 Amp silicone diodes, heat sinked.
1	12 Amp bridge rectifiers, heat sinked.
2	1 Amp bridge rectifiers.
2	1 Amp +5 V regulators, heat sinked.
1	1000 uF filter capacitor.
1	100000 uF filter capacitor.
1	1 Amp +12 V regulator.
1	14-pin IC socket (solder).
2	16-pin IC sockets (solder).
1	8-pin IC socket, wire wrapped (ww).
21	14-pin IC sockets (ww).
13	16-pin IC sockets (ww).
1	40-pin IC socket (ww).
1	6-switch DIP.
1	4-switch DIP.
2	16-pin IC plugs.
6	common anode 7-segment LEDs.
1	KIM keyboard.
1	4-slot Imsai motherboard.
4	Imsai 100-pin edge connectors.
4	feet, 40-conductor ribbon cable.
11	black banana jacks.
19	red banana jacks
2	phono jacks.
6	44-pin edge connectors.
4	44-pin plug in ww boards.
1	Pixie Verter (RF modulator).
ICs	4, 7400; 1, 7402; 1, 7404; 1, 74LS04; 1, 7408; 1, 7410; 1, 7420; 1, 7472; 1, 7476; 1, 7492; 1, 7493; 2, 74LS170; 1, LM339 (quad comparator); 3, 741 (op amps); 5, 8T97B (Tri-state buffers); 4, 4042BE; 1, 2502 (UART); 1, 1408L8 (D/A converter); 2, 74193.

Table 2. Summary of miscellaneous components.