

# AIM 65

MICROCOMPUTER  
**USER'S  
GUIDE**

# AIM 65



Rockwell International

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SECTION 1  
INTRODUCTION AND STARTUP

Welcome to the Rockwell R6500 Advanced Interactive Micro-computer--the AIM 65. AIM 65 is a complete general purpose microcomputer featuring advanced hardware and software. Rockwell has designed AIM 65 to be the ideal introduction to the rapidly expanding world of microprocessing. Not only is AIM 65 a learning tool, it is a powerful dedicated micro-computer that can serve as a central processor, or controller/monitor. AIM 65 is also an excellent, low-cost micro-computer development system.

AIM 65 comes to you fully assembled, tested, and warranted by Rockwell. It is a simple task to unpack it, connect the two modules, attach the required power--and be ready to go. You will quickly discover how easy the AIM 65 is to use and understand. If you are anxious to get started, go directly to Section 1.4. We suggest, however, that you read the initial sections to gain an overall understanding of AIM 65, this manual, and other documentation. We wish you many satisfying and rewarding hours of AIM 65 operation.

1.1 AIM 65 OVERVIEW

AIM 65 consists of two modules--the Master Module and the Keyboard Module--interconnected by a short plug-in ribbon cable. The Master Module holds a printer, a display, and the microcomputer components. Figure 1-1 identifies the

peripherals and microcomputer devices and shows where they are located.

The R6502 Central Processing Unit (CPU) is the heart of the AIM 65. The R6502 is a very widely used and powerful 8-bit microprocessor. It operates at 1 MHz on AIM 65 to provide a minimum instruction execution time of two microseconds. With 56 instructions and 13 addressing modes, the R6502 is highly flexible, but easy to program. The R6502 can address 4K bytes of RAM and 20K bytes of ROM on the Master Module plus an additional 40K bytes of user provided external RAM, ROM, or I/O.

The other R6500 devices on the AIM 65 include the R6522 Versatile Interface Adapter (VIA), the R6532 RAM-Input/Output Timer (RIOT), the R6520 Peripheral Interface Adapter (PIA), the R2332 Read Only Memory (ROM), and the R2114 Read/Write Random Access Memory (RAM).

The 20 column thermal printer provides a permanent record of user commands, data, and programs as well as AIM 65 status, prompts, and messages. Printing at 120 lines per minute, the 5 x 7 dot matrix printer provides rapid, quiet, and reliable operation. It can print the complete ASCII 64 character format.

The display provides visual feedback during keyboard operations. The display length of 20 characters allows complete correspondence with the printer. The display uses a 16-segment font to provide a full 64 character ASCII set. The high contrast characters are distinct and easy to read.

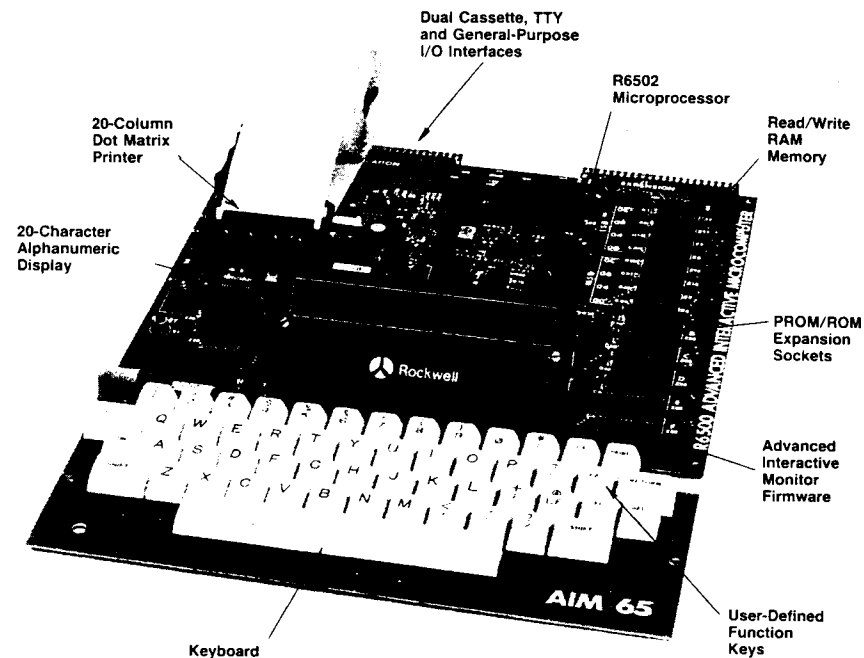


Figure 1-1. The AIM 65 Microcomputer

The Keyboard Module contains a 54-key full-size keyboard. The keyboard has 70 functions (26 alphabetic, 10 numeric, 22 special, 9 control, and 3 user-defined) used by AIM 65.

AIM 65 operation is controlled by a ROM-resident 8K Monitor which provides a comprehensive set of easy-to-use single keystroke commands. The Monitor commands greatly simplify the use of the CPU, memory, and I/O devices. The user can concentrate on application design and microprocessor software development at the functional level. By automatically translating functional commands to machine code, the Monitor makes development faster and more efficient.

The AIM 65 Monitor includes commands to:

Enter R6502 instructions in mnemonic form for direct translation to object code.

Disassemble R6502 instructions from object code to mnemonic form.

Execute user written programs with debugging aids such as instruction trace, register trace, and breakpoints.

Display and alter memory and registers.

Transfer object code to and from one or two audio cassette recorders or a teletype.

Allow user defined functions to interface with user provided peripherals.

An Editor allows easy entry, editing, and listing of R6502 source instructions, data, or general text. The Editor incorporates commands to:

Transfer text, enter programs or data into memory, or transfer source code to and from one or two audio cassette recorders or a teletypewriter.

Locate and change character strings.

Move the text line pointer.

List selectable lines on output devices.

The Master Module has three spare ROM sockets to allow the addition of 12K bytes of optional AIM 65 programs or user developed programs.

An optional R6502 Assembler, resident in a 4K R2332 ROM, may be installed in one of the spare ROM sockets. This two-pass program assembler converts R6502 source instructions into object code using symbolic labels and operands. Extensive error checking in an errors-only pass allows quick checking for proper instruction coding. By using the Assembler and Editor, the user can rapidly code, edit, assemble and debug programs.

The remaining spare ROM sockets may be used to add the optional AIM 65 8K BASIC Interpreter. This universal high level language is easy to learn and use. A fine, self-teaching introduction is Albrecht, Finkel, and Brown, BASIC for Home Computers, Wiley, New York, 1978.



AIM 65 is available in 1K and 4K RAM versions. In the 1K RAM version, the Master Module has six vacant RAM sockets for on-board expansion. The user can then add R2114 RAM chips.

More RAM, ROM, PROM, I/O, or other peripheral chips can be added by extending the AIM 65 address, data, and control bus lines to an expansion connector. The user may easily interface with these lines to meet specific requirements.

AIM 65 can be directly interfaced to external equipment through the application connector and the user dedicated R6522 VIA. The user R6522 has 16 bi-directional input/output lines, four control lines, and two timers.

| Interfaces for one or two low-cost audio cassette recorders allow permanent storing and loading of user programs and data. Recorder control lines enable semi-automatic remote control of the recorders. The optional Assembler allows the user to input source code from one audio cassette recorder and output object code to another recorder. This technique allows the on-board RAM to be dedicated to symbol tables during assembly.

## 1.2 AIM 65 USER MANUAL DESCRIPTION

This manual is designed to get you quickly into AIM 65 operation and then to tell you how to use it to its full potential. An in-depth description of the AIM 65 hardware and software is provided after the operating procedures.

The appendices contain common reference information.

Section 1, Introduction, explains how to properly set up AIM 65. The user should follow the instructions in Sections 1.4 through 1.8.

Section 2, Introduction to AIM 65 Operation, describes how to perform simple tasks with the AIM 65.

Section 3, AIM 65 Monitor, thoroughly describes each AIM 65 Monitor command and defines all options and AIM 65 prompts and messages.

Section 4, AIM 65 Editor, describes the AIM 65 Editor commands and explains the use of the text buffer.

Section 5, AIM 65 Assembler, provides a description of the assembly process, symbol table usage, assembler commands and options, assembler error detection capability, and error messages.

Section 6, R6500 Programming Concepts, offers an overview of R6500 assembly language programming.

Section 7, AIM 65 System Description, describes AIM 65 hardware and software. The interfaces with the keyboard, printer, and display are defined. The AIM 65 memory map is described and the AIM 65 software structure is shown. User available subroutines are identified along with the calling procedures and register utilization.

Section 8, R6522 Versatile Interface Adapter, describes the capabilities of the user R6522 and provides programming examples.

Section 9, Interfacing with Audio Cassette Recorders and Teletype, explains the interfaces with these user-provided peripherals. This section also describes audio tape recording formats, teletype connections and procedures, details on modifying user alterable variables in order to optimize your recorder interface, and procedures to input and output source and object code using a teletype paper tape punch and reader.

Section 10, Expanding the System, offers guidelines for connecting additional RAM, ROM, I/O or other peripheral devices to the AIM 65, using the expansion connector.

Section 11, Troubleshooting and Warranty, helps you isolate and correct certain problems. Hopefully, any problems are due to incomplete power or interface connections or improper switch positions that can be easily corrected. Should any uncorrectable problems occur, follow the instructions listed in this section for repair.

Appendices A through K offer detailed information for general or specific use that you may want to refer to often. Scan the appendices to become familiar with their content.

An assembly listing of the AIM 65 Monitor and Editor is provided in a separate volume, 29650N36L. This listing offers insight into the structure and design of a complete microcomputer program. Design techniques and algorithms included in the AIM 65 Monitor and Editor may be used in your own applications.

### 1.3 DESCRIPTION OF OTHER AIM 65 DOCUMENTATION

This manual does not describe either R6500 hardware or software design in detail. The R6500 Microcomputer System Hardware Manual describes the architecture, electrical and interface characteristics, and timing and other hardware considerations of all the R6500 devices used in the AIM 65. The R6500 Microcomputer System Programming Manual describes how each instruction operates in the R6502 CPU.

An R6500 Programming Reference Card and an AIM 65 Summary Card are included for handy reference during AIM 65 operation. A fold-out schematic poster of the complete AIM 65 is also enclosed.

### 1.4 HANDLING PRECAUTIONS

You should observe the following precautions to prevent damage to AIM 65 or interfacing equipment.

#### CAUTION - UNENCLOSED MODULES

Since AIM 65 has no protective enclosure, items dropped or set on the module may damage the printer, display, or other components. Liquid spilled on the modules may also damage the modules by inducing short circuits.

#### CAUTION - MOS DEVICES

Microcomputer devices are manufactured using the Metal-Oxide Semiconductor (MOS) process. The inadvertent application of high voltages may damage MOS devices.

You should take the following precautions:

- A. Discharge any static electrical charge accumulated on your body by touching a ground connection (e.g., a grounded equipment chassis) before touching the AIM 65. This precaution is especially important if you are working in a carpeted area or in an environment with low relative humidity.
- B. Make sure all test equipment, interfacing hardware, and electrical tools (e.g., soldering irons) are properly grounded before use with AIM 65.

#### CAUTION - EXPOSED VOLTAGES

The +5V and +24V supply voltages are routed to many exposed pins on the modules. Shorting these pins to ground or to other pins may cause improper operation or permanent damage.

#### WARNING - PROTRUDING LEADS

The bottom of the Master Module and Keyboard Module have component leads sticking through the mounting holes that may protrude past the solder cap. These clipped leads may be sharp and could puncture skin. To avoid injury, handle the modules by placing fingers between the component mounting holes.

#### 1.5 PARTS INVENTORY

Report any damage to the shipping container to your dealer or shipping agent.

You may wish to save the shipping container and packaging material should you need to ship or store the AIM 65 at some future date.

After carefully removing the AIM 65 and accompanying documentation and loose equipment from the shipping container, locate the following items:

- 4 Manuals - AIM 65 User's Guide
  - AIM 65 Monitor Program Listing
  - R6500 Microcomputer System Programming Manual
  - R6500 Microcomputer System Hardware Manual

- 1 R6500 Programming Reference Card
- 1 AIM 65 Summary Card
- 1 Loose Equipment Packet with:
  - 1 Keyboard to Master Module Cable
  - 15 Rubber Pads
- 1 Roll of Printer Paper
- 1 Warranty Card\*

\*Be sure to complete and mail the warranty card.

#### 1.6 SET UP

#### SUPPORTING PAD INSTALLATION

Remove any conductive foam from underneath the Master Module. Attach the supporting rubber pads on the bottom of

the Master and Keyboard Modules at the approximate locations shown in Figure 1-2. First remove the protective film from the pad's sticky surface; next, lightly attach each pad at the proper location. Turn the boards top side up and set them down on a flat surface. Press down firmly, and carefully, on the modules over the pad locations to permanently affix the pads.

#### SOCKETED COMPONENTS CHECK

Inspect the socketed components on the Master Module. If any socketed devices have loosened during shipment, reseal them by firmly and evenly pressing down on the top of the device with one hand while supporting the Master Module under the loosened device with the other hand in order to prevent flexing.

#### KEYBOARD CONNECTION

Ensure that the pins on the Keyboard to Master Module cable are straight and positioned properly. Connect one end of the cable into Keyboard Module Connector J1 and the other end into the Master Module Connector J4.

#### CAUTION

The keyboard to Master Module Cable allows limited movement and positioning of the Keyboard Module with respect to the Master Module. Extreme relocation will cause the cable to pull out from one or both connectors and may damage the cable connector pins.

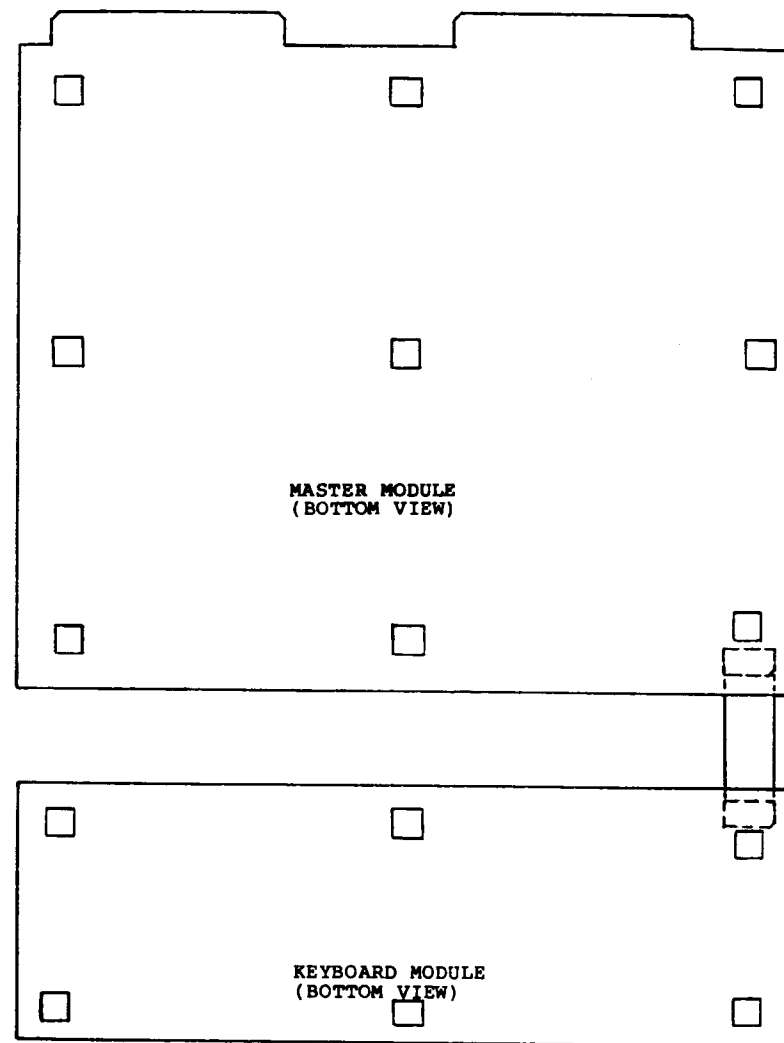


Figure 1-2. Supporting Pad Installation

A longer cable (up to three feet) may be used in place of the provided cable without affecting AIM 65 performance.

#### PAPER INSTALLATION

Separate the start of the printer paper from the supplied roll. Tear or cut the paper evenly, being careful to remove any adhesive or foreign material from the paper. Slide the roll of paper onto the wire paper holder. The paper should feed from under the roll toward the printer.

Pull the printer head release lever toward the keyboard edge of the Master Module to release the printer thermal head from the platen. Insert the paper into the back of the printer under the platen until it can be grasped from above, then feed the paper under the tear bar. Pull the paper up slightly until the entire leading edge is past the tear bar edge. Push the lever on the top of the printer toward the connector edge of the Master Module to position the printer thermal head on the platen.

#### CAUTION

Any adhesive or foreign material that comes in contact with the printer thermal elements may damage the printer.

#### 1.7 POWER SUPPLY REQUIREMENTS

AIM 65 requires only two voltages to operate: +5V and +24V. The +5V supplies power to the microcomputer devices, the audio circuitry, and the TTY circuitry.

The +24V supplies power to the printer. With only the +5V supplied, AIM 65 will operate properly, but both the printer and the TTY interface will not work. AIM 65 will display PRINTER DOWN if an attempt is made to print without the +24V available.

The +5V requirements are:

- +5V + 5% (4.75 to 5.25V)
- Regulated
- 2.0A

The +5V current may vary from less than 1.0A, for a 1K AIM 65 with two ROMs installed and the display segments unilluminated, to greater than 1.5A for a 4K AIM 65 with five ROMs installed and all display segments illuminated.

The +24V requirements are:

- +24V + 15% (20.4 to 27.6V)
- Unregulated
- 2.5A peak
- 0.5A average

The +24V current may vary from less than 0.2A, when the printer is not activated, to greater than 2.0A during a

print cycle. Note that the peak current is of short duration and therefore may not appear this high when monitoring with a slow response meter.

#### 1.8 POWER SUPPLY CONNECTION AND TURN-ON

Figure 1-3 shows the power supply connections. Do not hook-up and turn on power yet. Follow the procedure below to minimize the possibility of damaging your AIM 65 and power supply:

##### Step

1. Connect the +5V RETURN to TB1-2 (GND) and the +5V to TB1-3 (+5V). Recheck the connections.
2. Leave the +24V lines disconnected. Ensure that the +24V power line is touching neither the AIM 65 nor the +24V RETURN line.
3. Switch the KB/TTY switch to the KB position.
4. Switch the RUN/STEP switch to the RUN position.
5. Turn on +5V, or both the +5V and +24V (but leave the +24V supply disconnected) if they are supplied by the same power supply.
6. Verify that ROCKWELL AIM 65 flashes on the display followed by a steady display of PRINTER DOWN. If you are not sure, depress the RESET button and you should see it again. If the display is proper, go to Step 7.

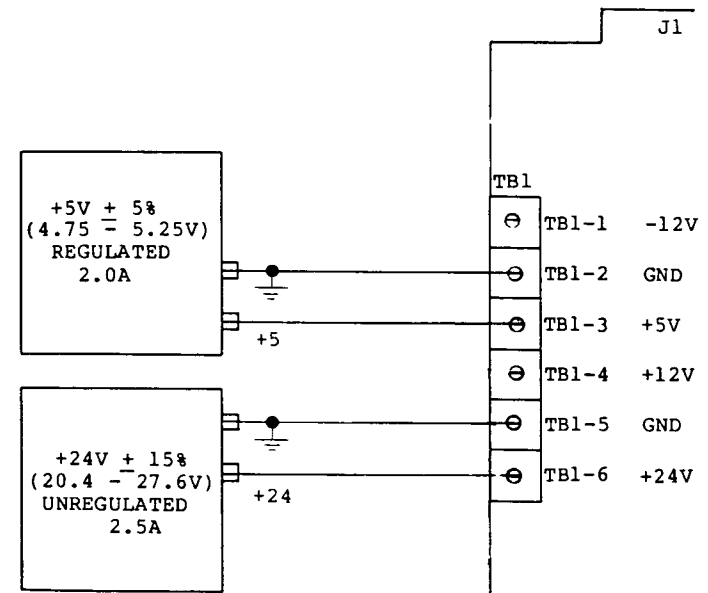


Figure 1-3. Power Supply Connections

If there is no display, the +5V power lines are probably incorrectly connected. Turn off the +5V power supply and repeat Steps 1 through 6. If the display still does not appear, refer to the troubleshooting procedure in Section 11.

7. Turn off the +5V power supply.
8. Connect the +24V RETURN to TB1-5 (GND) and the +24V to TB1-6 (+24V). Recheck the connections.

NOTE

Ground terminals TB1-2 and TB1-5 are connected on the Master Module. The +5V RETURN and the +24V RETURN may be connected together on either terminal if it is more convenient. If one power supply is used to supply both +5V and +24V, only one common RETURN is required, and may be connected to either TB1-2 or TB1-5.

9. Turn on the +5V and +24V power supplies. If they are separate, turn on the +5V supply first. If +24V is turned on first, the printer paper will continuously advance until +5V is applied. If +5V is turned on first, the PRINTER DOWN display will occur.
10. After both +5V and +24V are applied, press the RESET button. The ROCKWELL AIM 65 message will display and print followed by a display of < in the leftmost digit.

NOTE

The printer may have been inadvertently turned off during the AIM 65 turn-on process. Type PRINT to print the contents of the display regardless of the printer control. Type CTRL and PRINT simultaneously until <ON is displayed to turn the printer on. Then type the R key, which will display and print the register headings and contents (see Section 3.3.7).

If the printer does not operate, the +24V power lines are probably incorrectly connected; turn off the power supplies and repeat Steps 8, 9, and 10. If the display and printout still do not appear properly, refer to the troubleshooting procedure in Section 11.

11. The AIM 65 is now operative. Section 2 describes the basic concepts of using the AIM 65.

1.9 CONTROL SWITCHES

1.9.1 RESET Button

Depression of the RESET button will cause a hardware and software reset to be performed. All input/output devices, i.e., 6520, 6532, and 6522 (including the user 6522) and the 6502 CPU will be initialized to their reset state. Refer to the individual device description for the definition of the hardware reset operations.

When the RESET button is depressed, the current operation is interrupted and the AIM 65 Monitor initialization performed.

The Monitor checks to see if a "cold" reset or a "warm" reset is to be accomplished. A "cold" reset, or power-on initialization, will be performed if the Monitor determines that power has been interrupted. A "cold" reset causes all Monitor control parameters to be initialized including user alterable parameters. A "warm" reset performs initialization of only the Monitor control variables and does not initialize user alterable parameters. Refer to Section 7.6 for a description of the user alterable parameters.

A "warm" reset can be performed at any time by depressing the RESET button. This type of reset should be performed any time an unknown operation has taken place or if the AIM 65 appears lost or hung up in execution of a command. The AIM 65 Monitor control parameters can easily be altered if an unvalidated user program is executed using the Monitor User Function (F1, F2, or F3) or the Start Execution at Program Counter Address (G) commands. This will cause undetermined and probably improper AIM 65 Monitor operation if a reset is not performed. In this case, a reset is the only way to return complete control to the AIM 65 Monitor.

Some AIM 65 functions perform time critical operations such as reading or writing an audio tape file that does not have time for ESC key monitoring. In these cases, press RESET to abort the command.

A "cold" reset should be performed if it is desired to initialize the user alterable parameters to their default

values. The "cold" reset can be initiated by removing AIM 65 power for a couple of seconds then reapplying power. The power-on reset can also be performed without removing power by placing 00 in address A402 using the M and / Monitor commands then pressing the RESET button (see Section 3.4).

#### 1.9.2 KB/TTY switch

The position of the KB/TTY switch determines which keyboard controls the AIM 65 operation.

#### AIM 65 KEYBOARD CONTROL

To operate from the AIM 65 keyboard, place the KB/TTY switch in the KB position. When KB is selected, initial AIM 65 power application or depression of the RESET button will automatically enable inputs from the AIM 65 keyboard.

To switch keyboard control from the TTY when the TTY keyboard is active, place the KB/TTY switch in the KB position and type any key on the TTY keyboard or depress the AIM 65 RESET button.

#### TTY KEYBOARD CONTROL

To operate from the TTY keyboard, place the KB/TTY switch in the TTY position. If this is the initial transfer of control from the AIM 65 keyboard, or AIM 65 power is applied with the TTY selected, depress the AIM 65 RESET button followed by typing RUBOUT on the TTY keyboard.



If the TTY keyboard has previously been active and control switched over to the AIM 65 keyboard, the TTY keyboard can be reactivated by switching the KB/TTY switch to the TTY position and then typing any AIM 65 key.

Refer to Section 9.2 for a detailed description of TTY connection, and user procedures.

### 1.9.3 RUN/STEP Switch

The position of the RUN/STEP switch determines whether the user program is to execute in the RUN or single-step mode (see Section 3.6).

### 1.10 AIM 65 APPLICATIONS

How can you use your AIM 65? Let us take some time to offer some suggestions:

1. AIM 65 is an ideal low cost prototyping and development system for R6502 applications. AIM 65 is portable and easy to use. It provides a self-contained system with keyboard, display, monitor, editor, assembler, and printer.
2. AIM 65 is an ideal educational system for engineering and technology classes. It is low enough in cost so that schools can purchase many work-stations. Yet it offers such advanced features as mnemonic entry, ROM-based assembler and BASIC, and hard copy. Expensive terminals are unnecessary but students can still gain realistic experience.

But AIM 65 is more than just a prototyping or educational system. It is a full-fledged microcomputer with enough peripherals to handle the following applications:

1. Factory data collection terminal
2. Medical instrument controller
3. Navigational calculator
4. Integrated circuit tester
5. Remote instrument controller
6. Data logger
7. Power line monitor
8. Energy monitor
9. Message switching and buffering
10. Engine test controller
11. Alarm logger
12. Automatic Service monitor
13. Biomedical data acquisition system and signal processor
14. Process control supervisor
15. Frequency response analyzer
16. Transformer or motor controller
17. Solar heating controller
18. Security monitor

These are just a few of the AIM 65's potential applications. For others, you might wish to explore the following sources:

The Proceedings of the IEEE's Industrial Electronics and Control Instrumentation Group Annual Conference on "Industrial Applications of Microprocessors". These Proceedings (starting with 1975) are available from IEEE, 345 East 47th Street, New York, NY 10017.

The Proceedings of the IEEE special issues on microprocessor applications (June 1976, February 1978) available from IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854.

The monthly section entitled "Digital Control and Automation Systems" in Computer Design, available from Computer Design Publishing Corporation, 11 Goldsmith Street, Littleton, MA 01460.