

MACHINE INSTRUCTIONS

Instruction	Binary Code (for instruction)	Octal	Comment
IN 6	11011011 (IN)	333,006	Bring data from input 6 and store in register A (accumulator).
MOV B,A	01 (MOVE) 000 (B) 111 (A)	107	Take A and move its contents to B.
IN 30	11011011 (IN) 00011110 (30)	323,036	Bring input 30 into accumulator
ADD B	10000 (ADD) 000 (B)	200	Add contents of A to B. Put results in A.
OUT 128	11010011 (OUT) 10000000 (128)	323,200	Transmit contents of accumulator to output 128.

are really very straightforward and easy to master. The procedures that are always used consist of the following:

Defining the Problem. This is by far the hardest part of the programming. Don't worry about the computer or the computer language when doing this part of the preparation. Simply decide what is required to do the job you want to accomplish.

Establishing an Approach. The computer and computer language have nothing to do with this step, either. It involves outlining a step-by-step procedure to achieve the desired results and getting it down on paper.

Writing the Program. Once you are familiar with programming, you will find that this step is the simplest. It is merely a matter of translating step 2 into the appropriate language.

There are many books available on programming. Some of them are quite good and are particularly useful for learning techniques such as flow programming, looping, etc. However, in essence, they can all be boiled down to the three steps above.

Software Example. To get a feel for what programming the Altair 8800 is like, let's go through a sample program, which is similar to the test program that we first went through to check out the computer operation. Assume that we want to take the data available from input channel 6 and input channel 30 and add them, placing the result in output channel 128. The machine instructions are shown in the box.

The first instruction simply stores the data from channel 6 in register A (the accumulator). The next instruction moves this data from register A to register B. This clears A for the next

input. The third instruction brings the data from input channel 30 into the A register. The fourth instruction adds the contents of register A (data from channel 30) to register B (data from channel 6) and puts the results back into register A. The final instruction transmits the answer from A to output channel 128. Total computer time used to perform this operation with the Altair 8800 is 18 microseconds. To put it another way, the computer could perform 56,000 of these operations in one second.

The instructions could be entered into the processor in one of three ways. The first and easiest would be with the use of an assembler. This is essentially a piece of software that converts alphanumeric symbols to machine language (binary code). For example, the assembler would convert our first instruction (IN 6) to the correct binary code. The problem with using an assembler is that you need a computer terminal for an input device and the assembler itself requires about 6000 words of memory storage. If extensive program development is to take place, the assembler is a good tool to have.

The next easiest method of entering the instructions is with the use of

EXPANDING THE COMPUTER

In describing the assembly of the Altair 8800 Minicomputer in last month's article, it was noted that the interior of the cabinet provides plenty of room for expansion. The room can be used to add many functions to the basic computer. For example, the present memory board in the Altair 8800 can be expanded with the addition of three 256-word memories (Kit 8802-MS available from the manufacturer, MITS at \$34 per 256-word memory). Further additions require an expansion mother board having four connectors that can accommodate any four memory or input-output (I-O) cards. This expansion board (Kit 8800-EB) is available for \$44, while a 4K dynamic memory card (Kit 8840-MC) costs \$198. Various other kits—a vectored interrupt card and a real-time clock, among them—are also available.

the Very Low Cost Terminal featured in the December 1974 issue of POPULAR ELECTRONICS. With this terminal, the instructions could be entered by using the octal code. The procedure would be to write the program in assembly language and then enter the corresponding code for each instruction. This system, while not being as fast as the use of an assembler is less expensive.

The third method, using front panel entry, is of course inexpensive but time consuming.

This has been only a brief summary of the programming procedures for the computer. Complete programming information is provided with the Intel 8080 integrated circuit and with the Altair 8800 computer kit. ♦

