KOMPUTER KORNER

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IN THIS COLUMN, WE WILL INTRODUCE YOU TO additional details concerning the operations of an 8080A-based microcomputer that are controlled by software. It is the software instructions, or steps, that actually indicate to the microcomputer the tasks that it must perform. Just as you may start the day with a list of things to be done and a sequence in which they should be accomplished, the microcomputer, too, must be provided with a sequential list of program steps.

In general, we may not be familiar with what each microcomputer instruction does within the microprocessor chip. This does not deter us, however, from using them in all of our programs. Many of us are not familiar with the inner workings of an internal combustion engine, an automatic transmission, or a Xerox machine; our lack of knowledge does not prevent us from using them daily.

All of our programs are stored in fast semiconductor memory, either read/write memory or programmable read-only memory. The microprocessor IC *fetches* an instruction byte from the memory and then executes it. Each software instruction requires at least one fetch-and-execute action. Software instructions that contain several instruction bytes require two or three sequential fetch-and-execute actions. Again, exactly what is done within the microprocessor IC is not of interest to us, only the overall effect. All software is executed sequentially, one step after another, unless we purposely transfer control to instruction bytes located elsewhere in memory.

To conveniently handle the large number of software instructions in the 8080A microprocessor instruction set, it is customary to group them into several instruction groups. The Intel *8080 Microcomputer Systems User's Manual* subdivides the instruction set into five groups:

- Data Transfer Group—these instructions move data between registers or between memory and registers
- Arithmetic Group—add, subtract, increment or decrement data in registers or in memory
- Logical Group—and, or, exclusive-or, compare, rotate or complement data in registers or in memory
- Branch Group—conditional and unconditional jump instructions, subroutine call instructions and return instructions
- Stack, I/O and Machine Control Group—includes I/O instruc-

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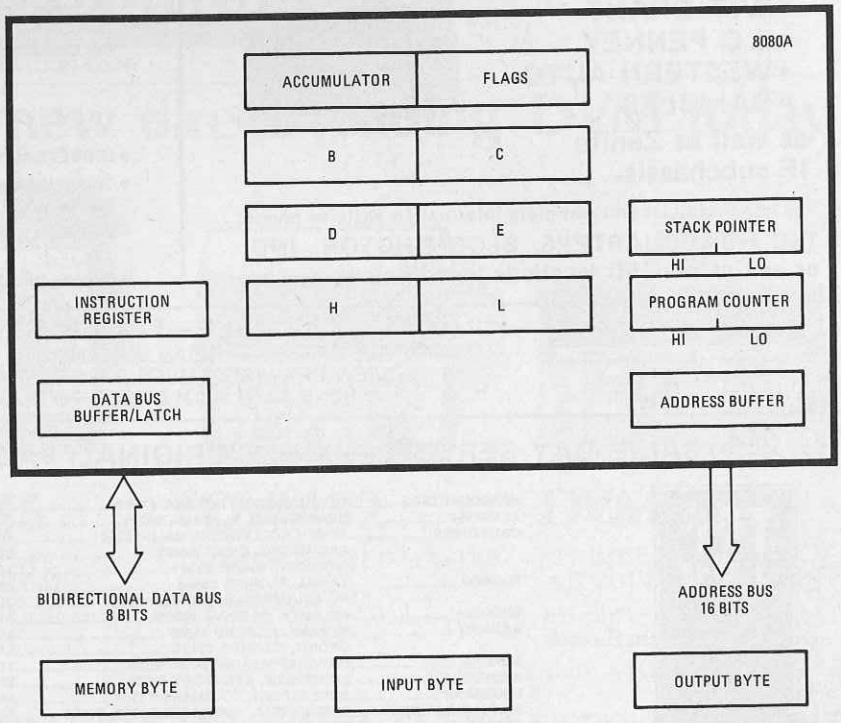

FIG 1

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tions, as well as instructions for maintaining the stack and internal control flags

Before we can make much sense of these instructions, we must know more about the internal architecture within the 8080 itself. We shall present such information in steps, since it can be overwhelming if tackled all at once.

Shown in Fig. 1 is a schematic diagram that depicts the significant aspects of the internal architecture within an 8080 or 8080A IC. Our emphasis in the diagram has been an accessible 8-bit and 16-bit *registers* that store information within the IC. You should exclude from consideration the Data Bus Buffer/Latch and the Address Buffer, which we show here to make the point that these are internal circuits that interface the internal digital circuitry with the outside world, i.e., the 8-bit *bidirectional data bus* and the 16-bit *address bus.* As you learn about the 8080, you will be specially interested in the *accumulator, flags, program counter, stack pointer,* and *general purpose registers* that are designated B, C, D, E, H, and L.

We will not say much about the *instruction register,* since its function is automatic and we have little control over it. The function of the instruction register can be best understood with the aid of Fig. 2, which shows that it is an 8-bit register that temporarily stores the 8-bit instruction code for an instruction that is to be executed. Within the microprocessor IC, an instruction decoder converts the instruction code into a series of actions that, together, cause a microcomputer operation to occur. The individual actions are clocked by the ϕ_1 and ϕ_2 clock signals that are input at pins 22 and 15, respectively, on the 8080 IC.

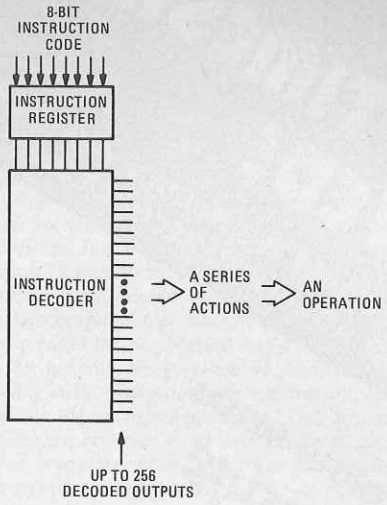

FIG 2

The general purpose registers B, C, D, E, H, and L are used for many varied purposes, *e.g.*, the storage of an 8-bit constant, the storage of a 16-bit pointer address, the storage of an intermediate result in an addition or subtraction, etc. Each general purpose register contains eight bits and can exchange data directly with the 8-bit external bidirectional data bus. Simple 8080 instructions permit you to transfer eight bits of data from one register to another; from a pair of registers to the program counter; from a register to the accumulator; and from a register to a memory location, and *vice versa.* You can use the contents of a register to perform addition, subtraction, and, or, exclusive-or, and compare operations with the contents of the accumulator. The contents of each register can be incremented or decremented. Register pairs, such as register H and register L, can be incremented or decremented as a 16-bit word.

The accumulator also acts as a general purpose register, but it has some special characteristics not possessed by the other six registers. The result of any arithmetic or logical operation is stored in the 8-bit accumulator. The I/O instructions (IN and OUT) transfer data only between the accumulator and external I/O devices. The contents of the accumulator can be transferred to any other general purpose register or to a memory location, and *vice versa.*

The five flags—zero, carry, parity, sign, and auxiliary carry—are flip-flops that indicate that certain conditions have arisen during the course of an arithmetic or logical instruction. Such flags are used by the microcomputer in making decisions, *i.e.*, with conditional jump, call, and return instructions; in multiple-precision arithmetic operations; and in logical masking operations.

The program counter is a 16-bit register in the 8080 IC that contains the address of the

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next instruction byte that must be executed in a program. You can load the program counter register either from a register pair or, more likely, from two instruction bytes in sequence located in memory.

region of memory that is allocated for the storage of temporary information, usually the contents of the internal registers within the 8080 IC.

This summarizes our brief discussion of the internal architecture of the 8080 microprocessor. Keep in mind that there are seven 8-bit registers, two 16-bit registers and five flags, *the contents of which you can control using software.* Much of what an 8080 microcomputer does is to move 8-bit bytes from one location to another. This will become more apparent in subsequent columns. **R-E**

DEFINITIONS

accumulator—The register within a computer where the results of all arithmetic and logical operations are placed.

address bus—A unidirectional bus over which digital information appears to identify either a particular memory location or a particular I/O device.

bidirectional data bus—A data bus in which digital information can be transferred in either direction. With reference to an 8080A-based microcomputer, the bidirectional data path by which data is transferred between the microprocessor chip, memory, and input-output devices.

fetch—In a computer, the collective actions of acquiring a memory address and then an instruction or data byte from memory.

flag—A single flip-flop that indicates that a certain condition has arisen as, for example, during the course of an arithmetic or logical operation in a computer program.

general purpose registers—In the 8080 microprocessor, the 8-bit B, C, D, E, H, and L registers.

program counter—In a computer, the register that contains the address of the next instruction byte that must be executed in a computer program.

register—A short-term digital electronic storage circuit the capacity of which is usually one computer word or byte.

software—The totality of programs and routines used to extend the capabilities of computers. Examples include compilers, assemblers, narrators, routines, and subroutines.

stack—A region of memory that stores temporary information, usually the contents of the internal registers within a microprocessor chip.

stack pointer—A register that contains the address of the last byte that has been placed on the stack in an 8080 microcomputer.

The stack pointer is a 16-bit register that contains the address of the last byte that has been placed on the stack. The stack is a

Original operators celebrate 50 years of overseas phone

Two retired overseas telephone operators commemorated a half century of transatlantic telephone service with a call placed January 7, 1977, exactly 50 years after the first overseas phone call got through.

Ms. Rose de Palma, 73, one of the four original transatlantic operators for AT&T's Long Lines, called Ms. Isabel Ivy Baker, with whom she had worked from the earliest days of the transatlantic telephone. Ms. de Palma, brought from Florida to make the historic call, had retired from the Bell System in 1966 after 46 years of service. Ms. Baker, now 74 years old, left the British Post Office in 1940 and now lives in Thornton Heath, Surrey, England.

The two old-time operators reminisced before turning the phones over to dignitaries of AT&T in New York and its opposite number, the British Post Office in London.

The 1977 call was dialled by International Direct Distance Dialing, a service that permits one-fourth of all Bell System subscribers to dial direct to as many as 36 countries. There have been a few other changes in 50 years. The cost of a three-minute call in 1927 was $75 (equivalent to about $250 in 1977 dollars). The same three-minute call can be placed today for $4.05.

Computers now made useful for small-business man

Altair Software Distribution Co. is putting out software packages to fit the needs of retail stores, small wholesale distribution centers, industrial users and professional firms, among others. Altair is a subsidiary of MITS, microcomputer manufacturer of Albuquerque, NM.

The packages are designed to allow a purchaser to select the components of a system that will fit his needs closely. The accounting system, for example, is composed of four packages, *General Ledger, Payroll, Receivables* and *Payables*. The *Word Processing* package is a flexible text editor system that allows contracts or other lengthy documents to be stored, edited and printed. Documents can call for inserts from other files, making repetitive letters, etc., easy to produce.

The *Inventory Management* package is a flexible data-base management system that allows a business to keep complete inventory records "on line." In its off-the-shelf form, it is structured for a typical retail store whose inventory reorder policy is based on minimum reorder points. **R-E**