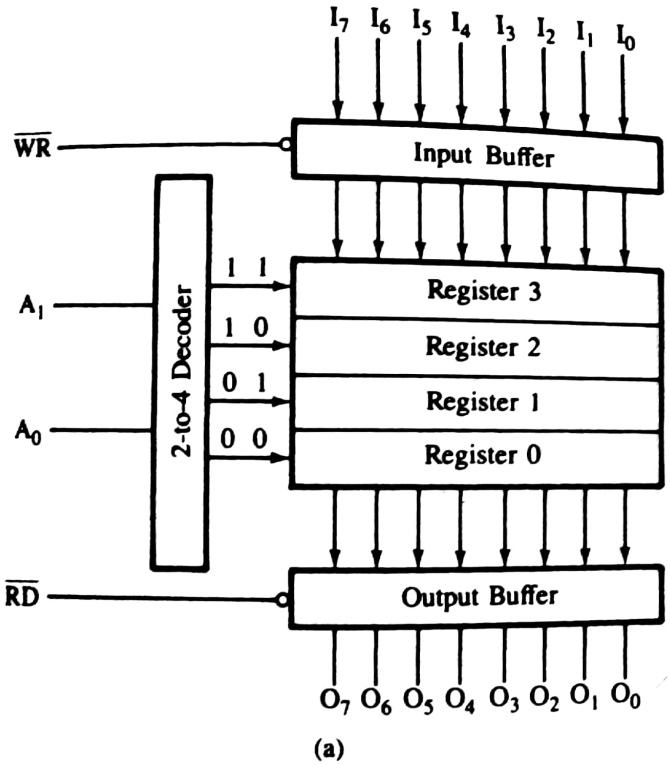

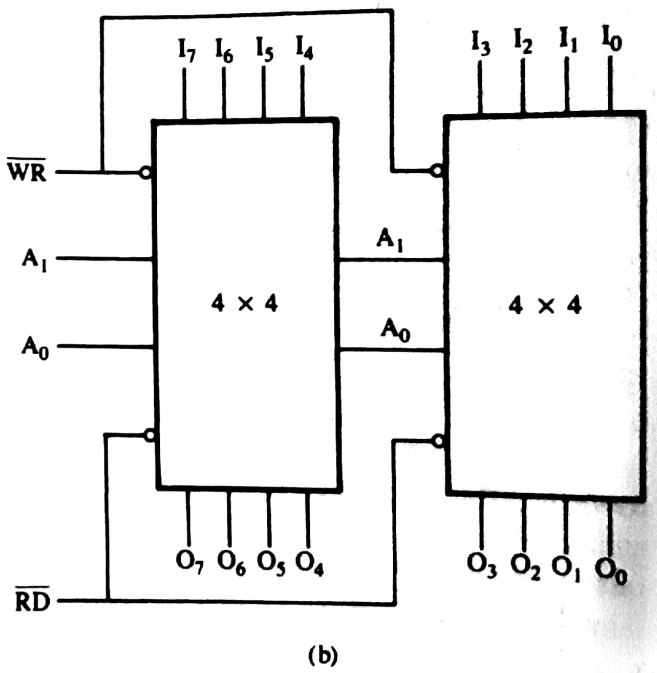

FIGURE 3.6
4 × 8-Bit Register

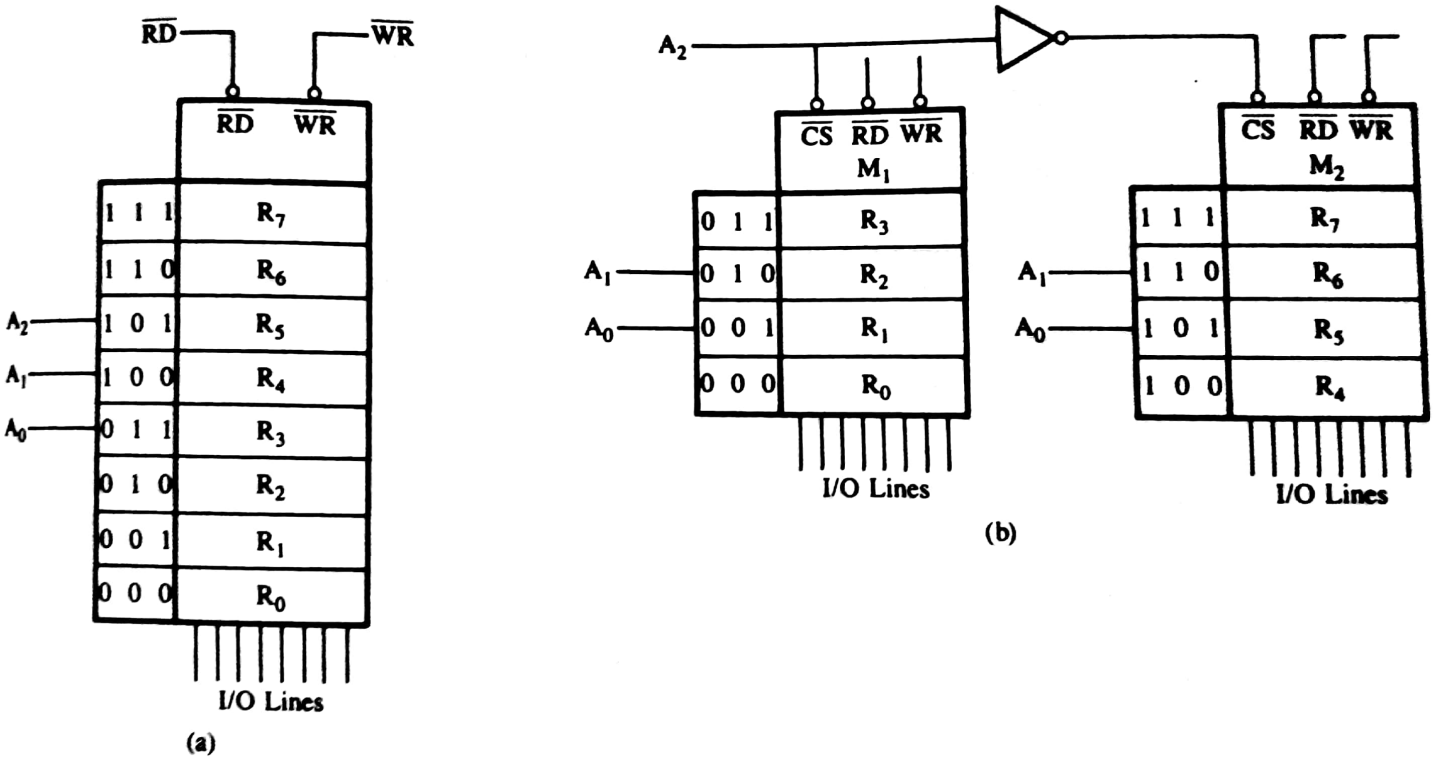

FIGURE 3.7
Two Memory Chips with Four Registers Each and Chip Select

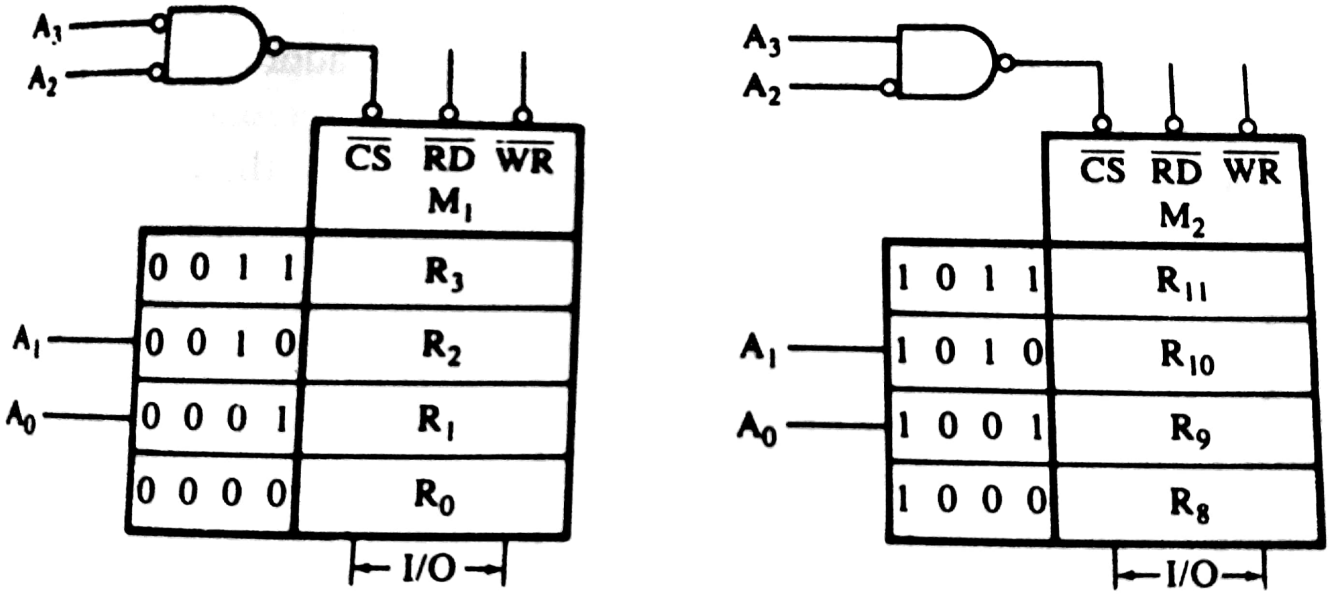

FIGURE 3.8
Addressing Eight Registers with Four Address Lines

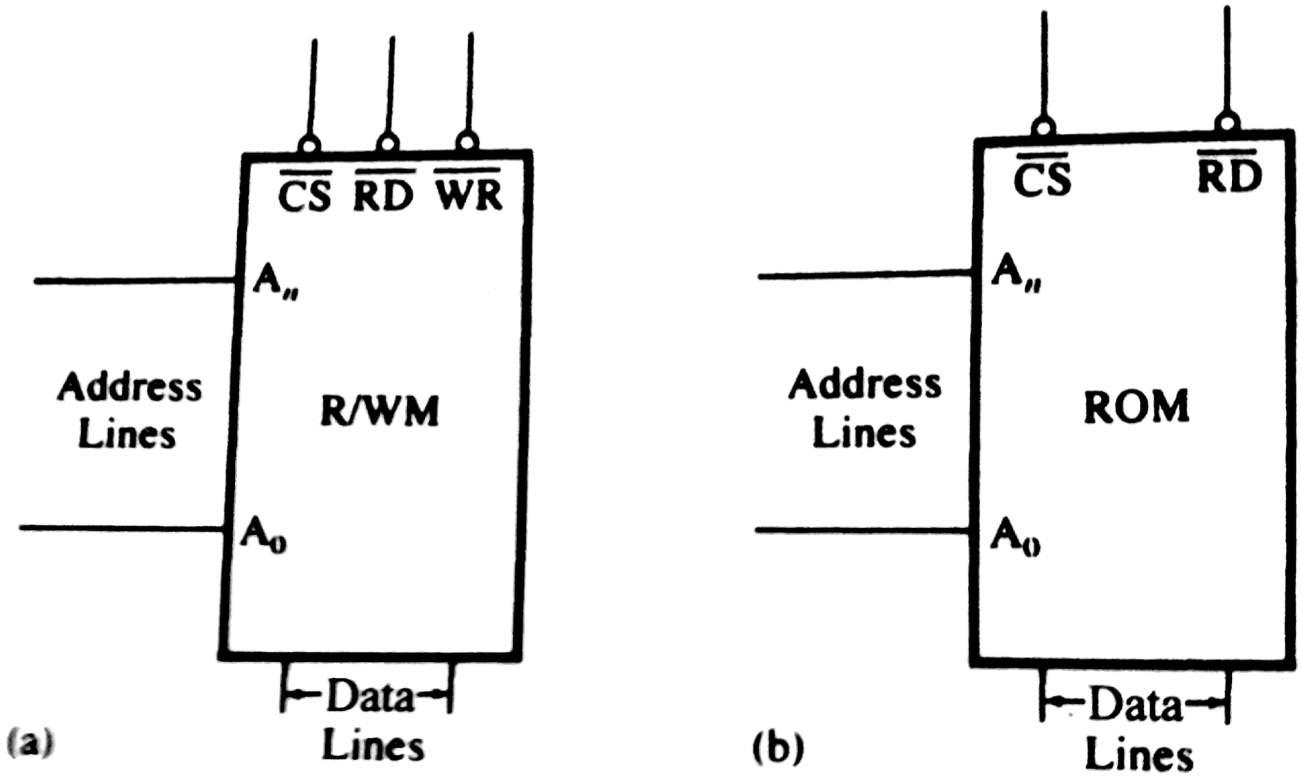

FIGURE 3.9
R/W Memory Model (a) and ROM Model (b)

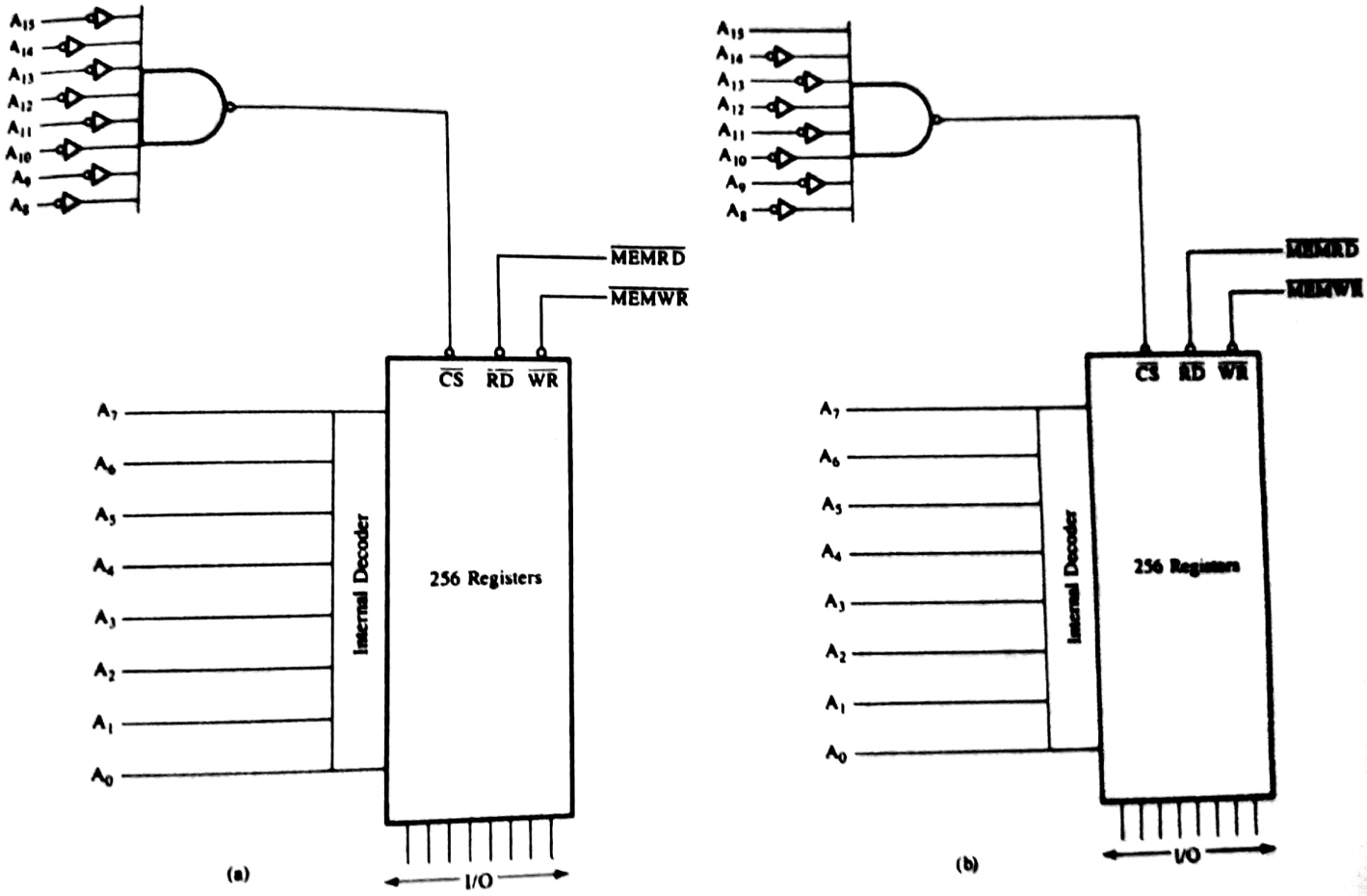

FIGURE 3.10
Memory Maps: 256 Bytes of Memory

R/WM (READ/WRITE MEMORY)

As the name suggests, the microprocessor can write into or read from this memory; it is popularly known as Random Access memory (RAM). It is used primarily for information that is likely to be altered, such as writing programs or receiving data. This memory is volatile, meaning that when the power is turned off, all the contents are destroyed. Two types of R/W memories—static and dynamic—are available; they are described in the following paragraphs.

Static Memory (SRAM) This memory is made up of flip-flops, and it stores the bit as a voltage. Each memory cell requires six transistors; therefore, the memory chip has low density but high speed. This memory is more expensive and consumes more power than the dynamic memory described in the next paragraph. In high-speed processors (such as Intel 486 and Pentium), SRAM known as cache memory is included on the processor chip. In addition, high-speed cache memory is also included external to the processor to improve the performance of a system.

Dynamic Memory (DRAM) This memory is made up of MOS transistor gates, and it stores the bit as a charge. The advantages of dynamic memory are that it has high density and low power consumption and is cheaper than static memory. The disadvantage is that the charge (bit information) leaks; therefore, stored information needs to be read and written again every few milliseconds. This is called refreshing the memory, and it requires extra circuitry, adding to the cost of the system. It is generally economical to use dynamic memory when the system memory size is at least 8K; for small systems, the static mem-

ory is appropriate. However, in recent years, the processor speed has reached beyond 200 MHz, and 1000 MHz processors are in the design stage. In comparison to the processor speed, the DRAM is too slow. To increase the speed of DRAM various techniques are being used. These techniques have resulted in high-speed memory chips such as EDO (Extended Data Out), SDRAM (Synchronous DRAM), and RDRAM (Rambus DRAM).

ROM (READ-ONLY MEMORY)

The ROM is a nonvolatile memory; it retains stored information even if the power is turned off. This memory is used for programs and data that need not be altered. As the name suggests, the information can be read only, which means once a bit pattern is stored, it is permanent or at least semipermanent. The permanent group includes two types of memory: masked ROM and PROM. The semipermanent group also includes two types of memory: EPROM and EE-PROM, as shown in Figure 3.13. The concept underlying the ROM can be explained with the diodes arranged in a matrix format, as shown in Figure 3.14. The horizontal lines are connected to vertical lines only through the diodes; they are not connected where they appear to cross in the diagram. Each of the eight horizontal rows can be viewed as a register with binary addresses ranging from 000 to 111; information is stored by the diodes in the register as 0s or 1s. The presence of a diode stores 1, and its absence stores 0. When a register is selected, the voltage of that line goes high, and the output lines, where diodes are connected, go high. For example, when the memory register 111 is selected, the data byte 0111 1000 (78H) can be read at the data lines D_7–D_0.

The diode representation is a simplified version of the actual MOSFET memory cell. The manufacturer of the ROM designs the MOSFET matrix according to the infor-

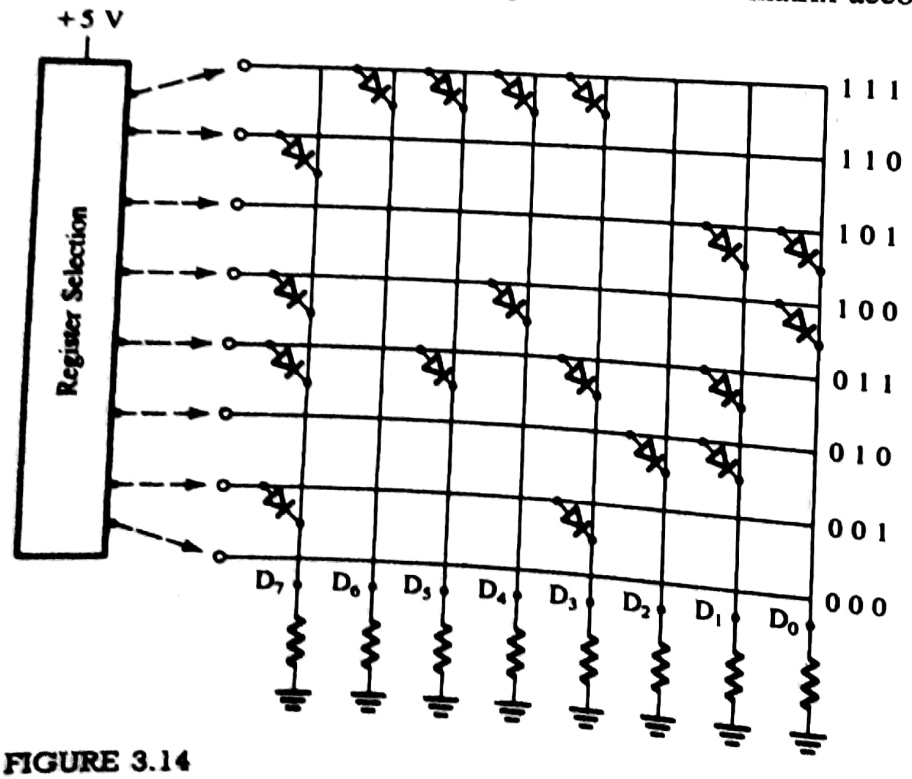

FIGURE 3.14
Functional Representation of ROM Memory Cell

mation to be stored; therefore, information is permanently recorded in the ROM, as a song is recorded on a record. Five types of ROM—masked ROM, PROM, EPROM, EE-PROM, and Flash Memory—are described in the following paragraphs.

Masked ROM In this ROM, a bit pattern is permanently recorded by the masking and metalization process. Memory manufacturers are generally equipped to do this process. It is an expensive and specialized process, but economical for large production quantities.

PROM (Programmable Read-Only Memory) This memory has nichrome or polysilicon wires arranged in a matrix; these wires can be functionally viewed as diodes or fuses. This memory can be programmed by the user with a special PROM programmer that selectively burns the fuses according to the bit pattern to be stored. The process is known as "burning the PROM," and the information stored is permanent.

EPROM (Erasable Programmable Read-Only Memory) This memory stores a bit by charging the floating gate of an FE. Information is stored by using an EPROM programmer, which applies high voltages to charge the gate. All the information can be erased by exposing the chip to ultraviolet light through its quartz window, and the chip can be reprogrammed. Because the chip can be reused many times, this memory is ideally suited for product development, experimental projects, and college laboratories. The disadvantages of EPROM are (1) it must be taken out of the circuit to erase it, (2) the entire chip must be erased, and (3) the erasing process takes 15 to 20 minutes.

EE-PROM (Electrically Erasable PROM) This memory is functionally similar to EPROM, except that information can be altered by using electrical signals at the register level rather than erasing all the information. This has an advantage in field and remot control applications. In microprocessor systems, software update is a common occurrence. If EE-PROMs are used in the systems, they can be updated from a central computer by using a remote link via telephone lines. Similarly, in a process control where timing information needs to be changed, it can be changed by sending electrical signals from a central place. This memory also includes a Chip Erase mode, whereby the entire chip can be erased in 10 ms vs. 15 to 20 min. to erase an EPROM. However, this memory is expensive compared to EPROM or flash memory (described in the nxt paragraph).

Flash Memory This is a variation of EE-PROM that is widely used. The major difference between the flash memory and EE-POM is in the erasure procedure: The EE-PROM can be erased at a register level, but the flash memory must be erased either in it entirety or at the sector (block) level. These memory chips can be erased and programmed at least a million times. The power supply requirement for programming these chips was around 12 V, but now chips are available that can be programmed using a power supply as low as 1.8 V. Therefore, this memory is ideally suited for low-power systems.

In a microprocessor-based product, programs are generally written in ROM, and data that are likely to vary are stored in R/WM. For example, in a microprocessor-controlled oven, programs that run the oven are permanently stored in ROM, and data such as baking period, starting time, and temperature are entered in R/W memory through