CPU

Memory

PC

MAR

IR

MBR

I/O AR

I/O BR

Instruction
Instruction
Instruction

Data
Data
Data
Data

I/O Module

Buffers

PC = Program counter
IR = Instruction register
MAR = Memory address register
MBR = Memory buffer register
I/O AR = I/O address register
I/O BR = I/O buffer register

Fig. 5.9 Computer Components: Top-Level View

```
0              3 4                                                      15
┌──────────────┬────────────────────────────────────────────────────────┐
│   Op Code    │                      Address                            │
└──────────────┴────────────────────────────────────────────────────────┘
```

(a) Instruction format

```
0    1                                                                   15
┌────┬───────────────────────────────────────────────────────────────────┐
│ S  │                         Magnitude                                  │
└────┴───────────────────────────────────────────────────────────────────┘
```

(b) Integer format

Program Counter (PC) = Address of instruction
Instruction Register (IR) = Instruction being executed
Accumulator (AC) = Temporary storage

(c) Internal CPU registers

0001 = Load AC from Memory
0010 = Store AC to Memory
0101 = Add to AC from Memory

(d) Partial list of opcodes

Fig. 5.10 Characteristics of a Hypothetical Machine

Memory — CPU Registers

Step 1

300	1 9 4 0		3 0 0	PC	
301	5 9 4 1			AC	
302	2 9 4 1		1 9 4 0	IR	
⋮					
940	0 0 0 3				
941	0 0 0 2				

Step 2

300	1 9 4 0		3 0 0	PC	
301	5 9 4 1		0 0 0 3	AC	
302	2 9 4 1		1 9 4 0	IR	
⋮					
940	0 0 0 3				
941	0 0 0 2				

Step 3

300	1 9 4 0		3 0 1	PC	
301	5 9 4 1		0 0 0 3	AC	
302	2 9 4 1		5 9 4 1	IR	
⋮					
940	0 0 0 3				
941	0 0 0 2				

Step 4

300	1 9 4 0		3 0 1	PC	
301	5 9 4 1		0 0 0 5	AC	
302	2 9 4 1		5 9 4 1	IR	
⋮					
940	0 0 0 3				
941	0 0 0 2		$3 + 2 = 5$		

Step 5

300	1 9 4 0		3 0 2	PC	
301	5 9 4 1		0 0 0 5	AC	
302	2 9 4 1		2 9 4 1	IR	
⋮					
940	0 0 0 3				
941	0 0 0 2				

Step 6

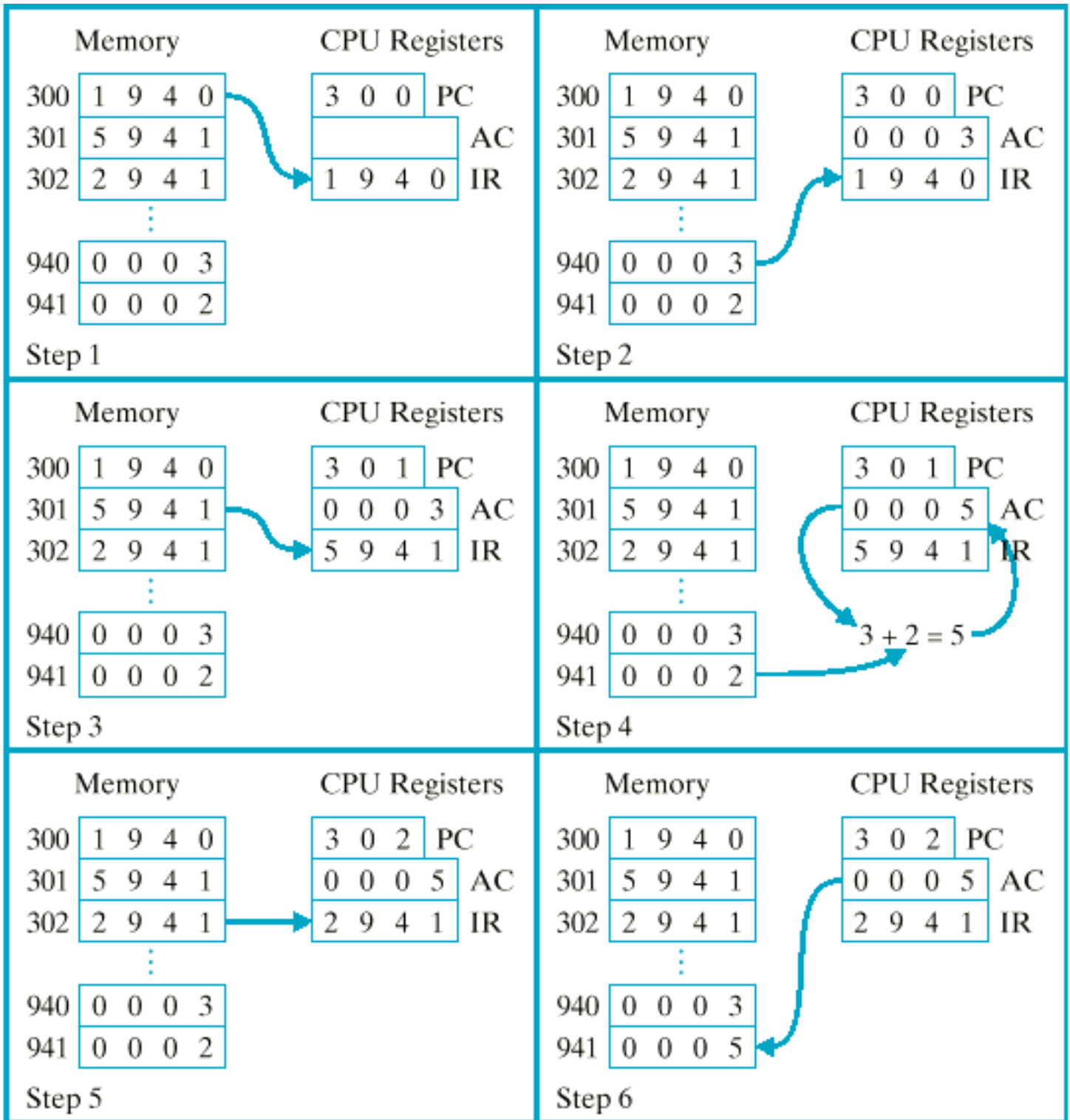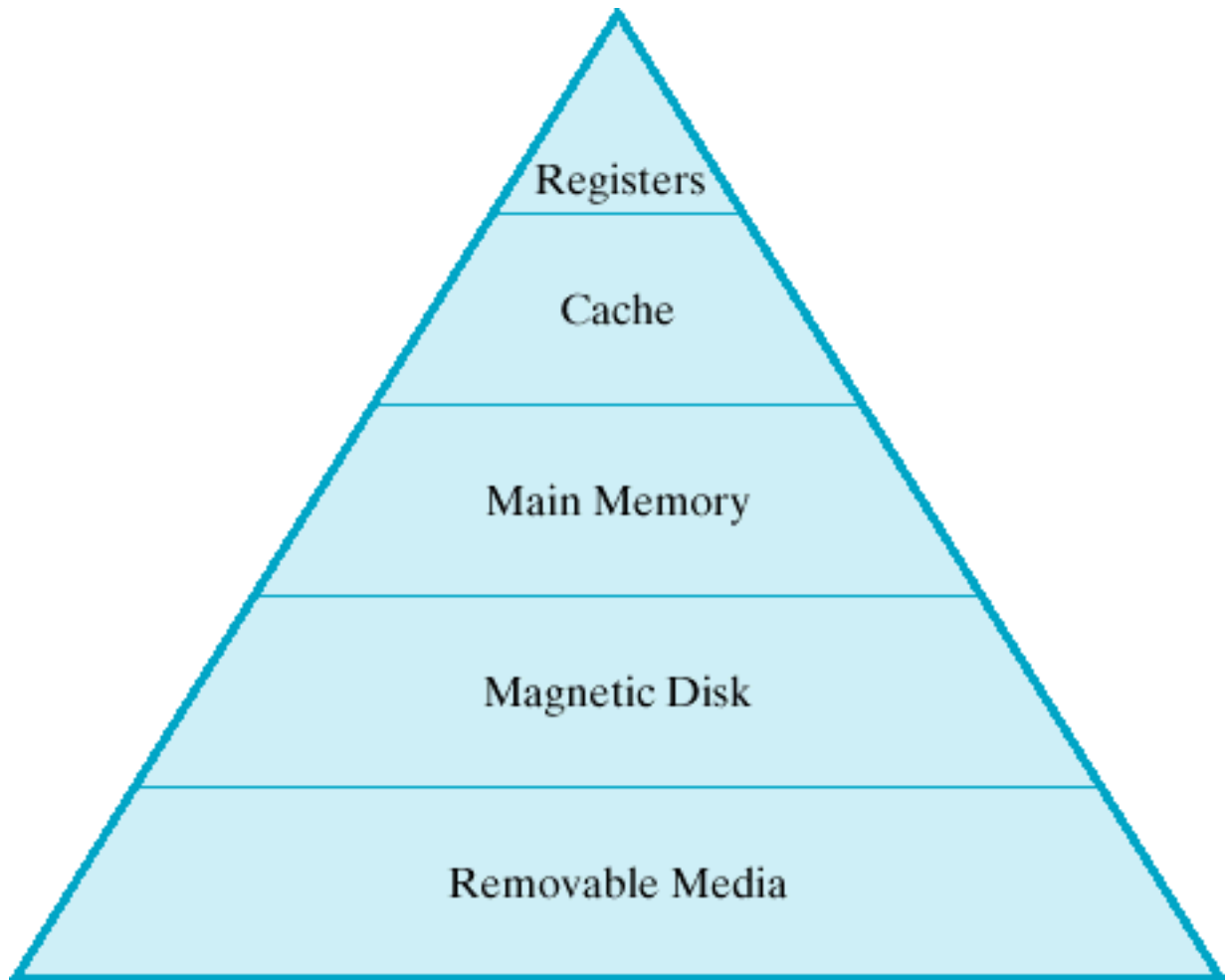|					
300	1 9 4 0		3 0 2	PC	
301	5 9 4 1		0 0 0 5	AC	
302	2 9 4 1		2 9 4 1	IR	
⋮					
940	0 0 0 3				
941	0 0 0 5				

Fig. 5.11 Example of Program Execution

Fig. 5.12 The Memory Hierarchy