Chapter – 4

Central Processing Unit

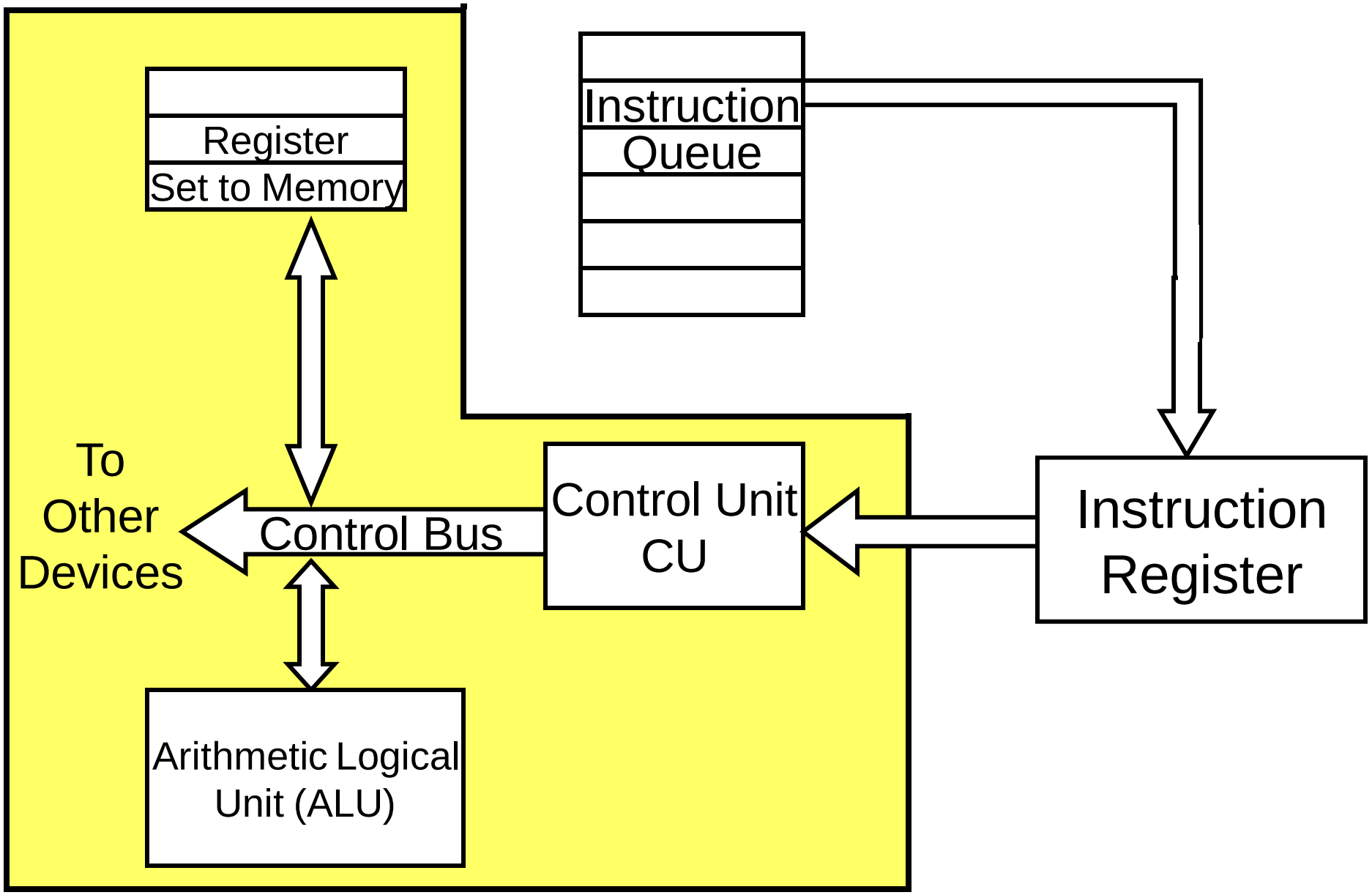
Introduction :

- Central Processing Unit (CPU) is the heart of digital computer system.
- So far we have studied the single register organization of CPU. In that organization whole instruction set was centered around single, general purpose register known as accumulator.
- Processors typically supports two types of arithmetic (1) integer and (2) float.

❑ CPU :

- ❖ CPU is the brain of computer.
- ❖ It performs a variety of functions by the type of instructions that are incorporated in the computer.
- ❖ Although its main function in executing programs, it also control input devices, output devices and other components of a computer.
- ❖ Under its control program and data are stored in memory and displayed on the screen shown in the figure.

❑ CPU :


Register
Set to Memory
Instruction
Queue
To
Other
Devices
Control Bus
Control Unit
CU
Instruction
Register
Arithmetic Logical
Unit (ALU)

❑ CPU :

- The CPU of small computer may contain a single microprocessor.
- The CPU of a large computer may contain a number of microprocessor on one or more circuit boards.
- A microprocessor consists of control unit and arithmetic and logic unit (ALU). The major part of a CPU are :

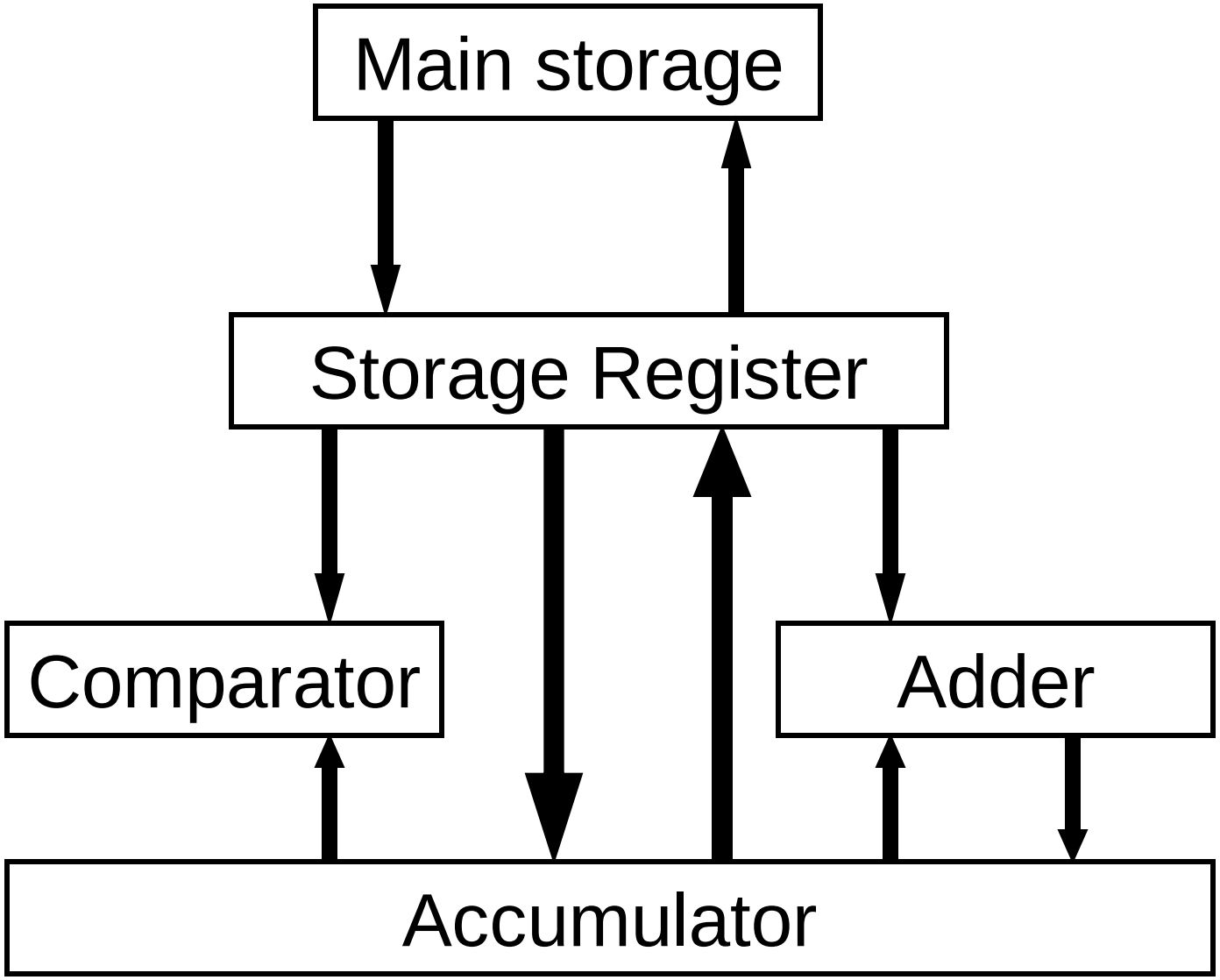
  (1) Arithmetic and Logical Unit (ALU)

  (2) Control Unit (CU)
- Main memory is also a part of CPU in computers.

❑ Major Component of CPU :

- The arithmetic logic unit (ALU) of computer system is place where the actual execution of instruction takes place during the processing operation.
- It is a multi operating combinational logic digital concept.
- It can perform set of basic arithmetic & logic operations.
- All calculations are performed and all comparisons (decisions) are made in the ALU.
- This part of the microprocessor is responsible for performing all types of arithmetical and logical (such as AND, OR, XOR) operation.

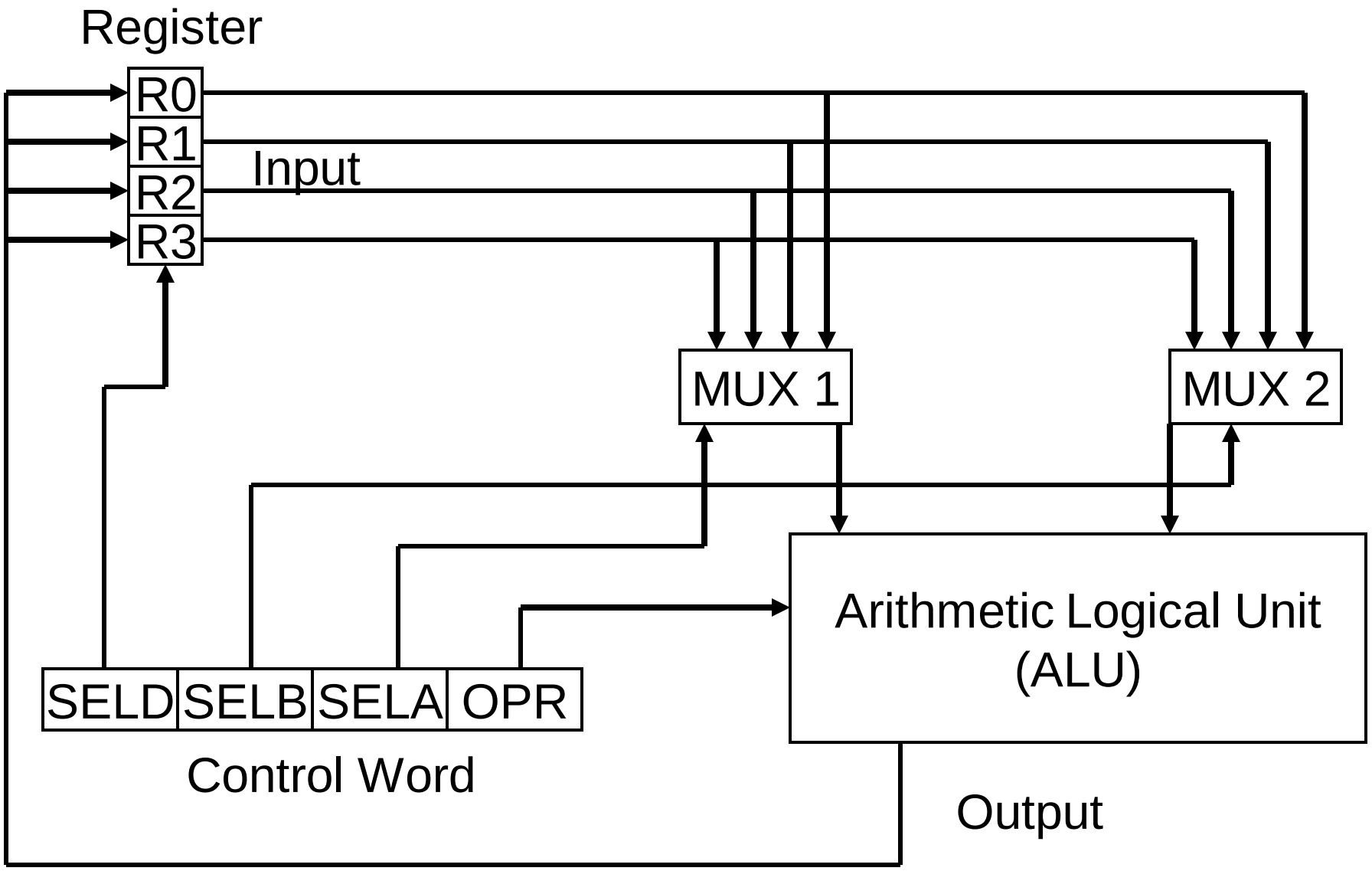
❑ Block diagram of ALU :



❑ Block diagram of ALU :

- The data which are entered in the accumulator is return to memory through the storage register.
- The data present either in the storage register or in the accumulator register may be transferred to the adder for the required addition or subtraction operation.
- After an operation has been performed, the result is stored back in the accumulator.
- This can be transferred to memory or any other register by using appropriate instructions.

❑ Block diagram of bus organization for four registers :



❑ Block diagram of bus organization for four registers :

- The ALU provides arithmetic and logic operation. In addition the CPU must provide shift operation.
- The shift output may be placed in the input of the ALU to provide a pre-shift capability or at the output of the ALU provide post-shift.
- In some cases the shift operations are included with ALU.

❑ Control Unit : (CU)

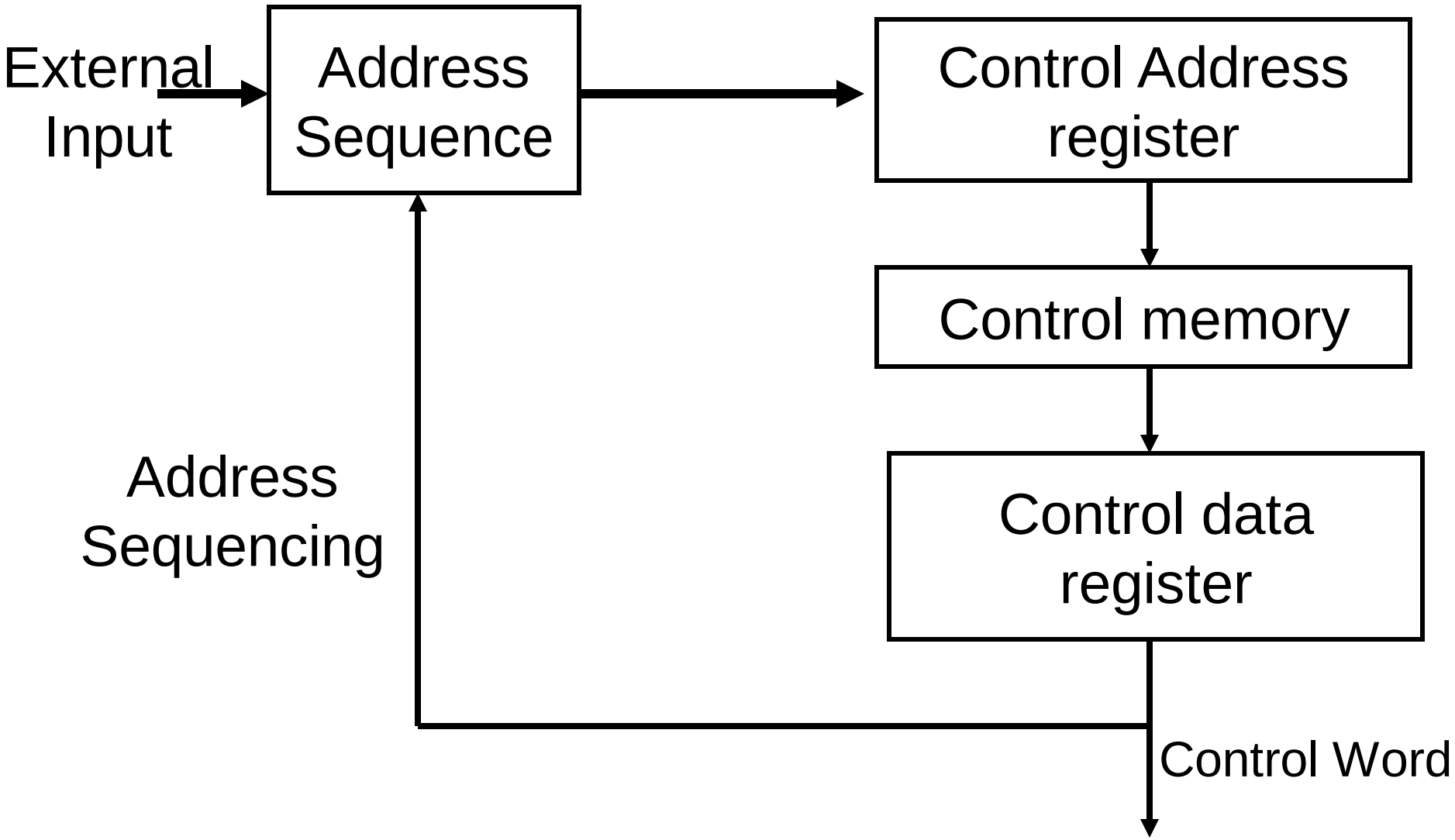
- The block diagram of control unit is shown below. Basically there are two types of control organizations.
  - Hardwired
  - Micro programmed control
- The block diagram includes two decoder, sequence counter and control logic gates.
- Here instruction register (IR) is divided in to three parts (1) operand for address (2) types of mode (3) direct or indirect.
- Eight output of decoder are designed by D_0 to D_7.

❑ Control Unit : (CU)

1) Bit 0-11 for operand
2) Bit 12-14 for operation code
3) Bit 15 direct or indirect

- The 4 sequence can count in binary form 0 to 15, which is connected to 4*16 decoder. timing signals are T_0 to T_{16} . The internal logic of the control gates are from it.

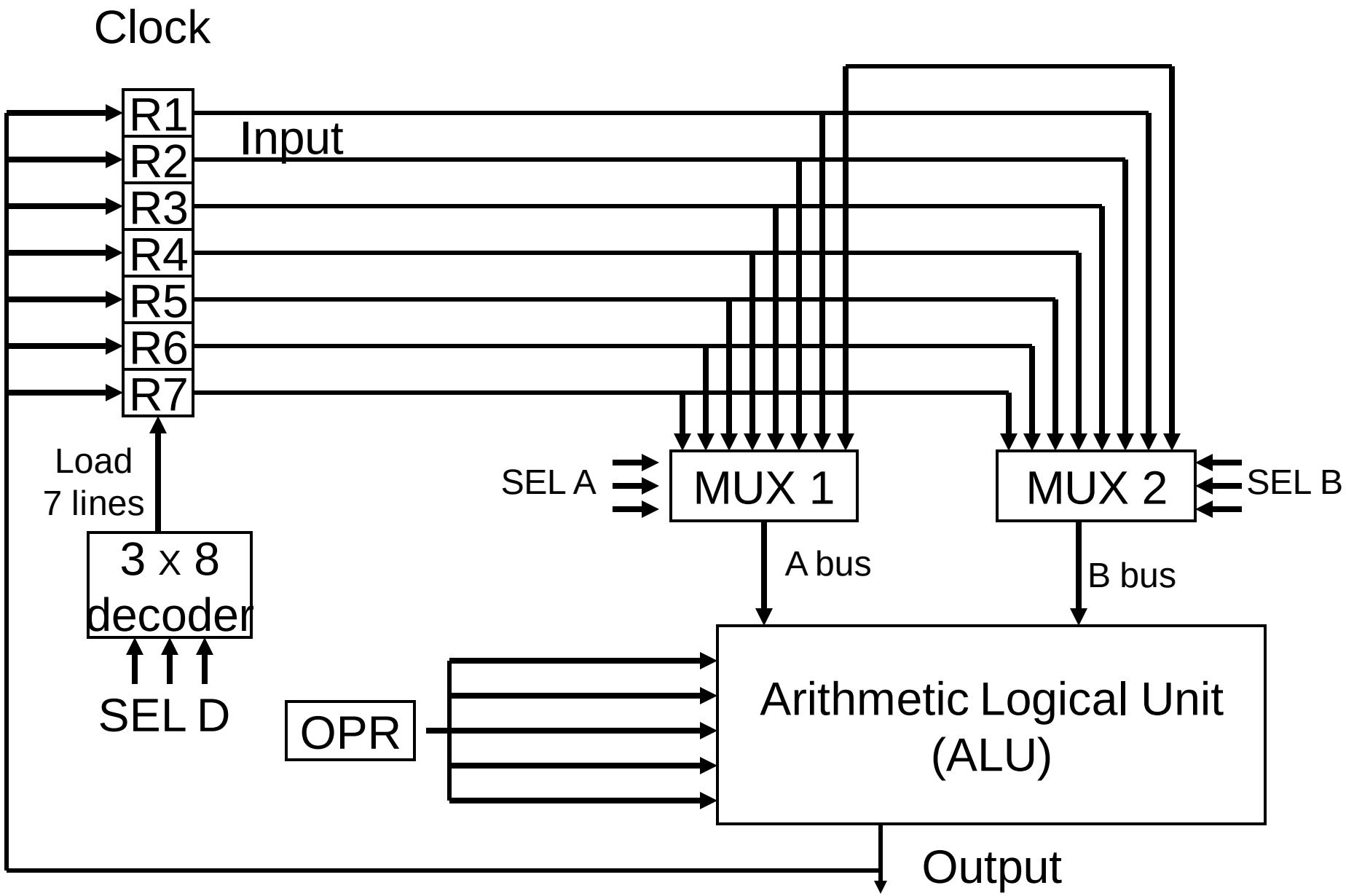
❑ Control Unit : (CU)



❑ General Register :

- A bus organization for seven CPU registers is shown below.
- The output of each register is connected to two multiplexer (MUX) to perform the two buses A and B.
- The operation selected in the ALU determines the arithmetic or logic micro-operation that is to be performed.
- The result of the micro operation is available for output data and also goes into the inputs of all the registers.
- The register that receives the information from the output bus is selected by the decoder.
- The control unit that operates the CPU bus system directs the information flow through the registers and ALU selected various components in the system.

❑ General Register :



❑ Control word :

- There are 14 binary selection inputs in the unit, and their combined value specifies a control word.

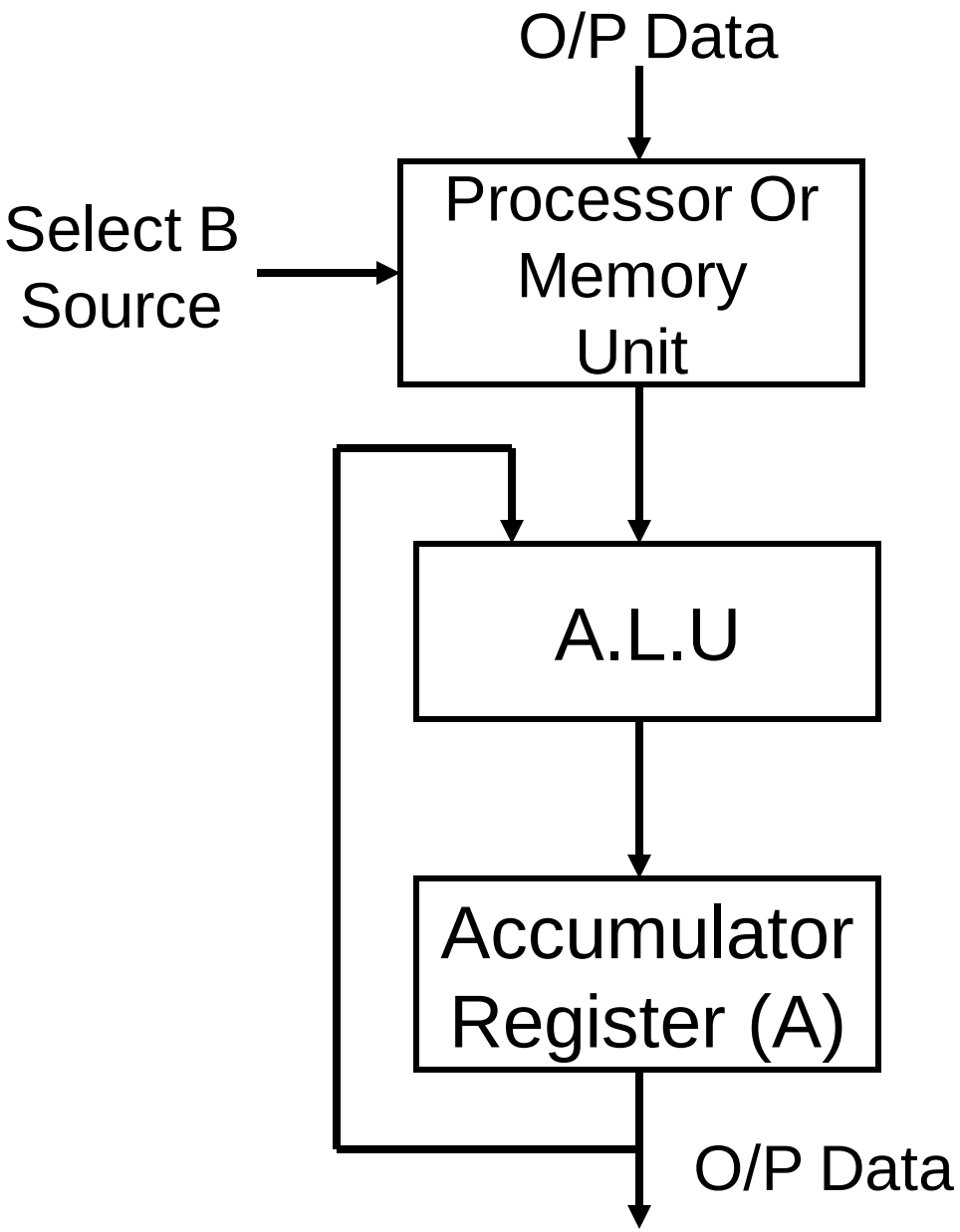
SEL A	SEL B	SEL D	OPR
3	3	3	5

- It consists of four fields. The fields contain three bit each, and one field has five bits.
- The three bits of SEL A select a source register for the A input of the ALU. The three bits of SEL B select a register for the B input of the ALU. The three bits of SEL D select a destination register using decoder and its seven load outputs.
- The five bits of OPR select one of the operations in the ALU.

❑ Accumulator Register :

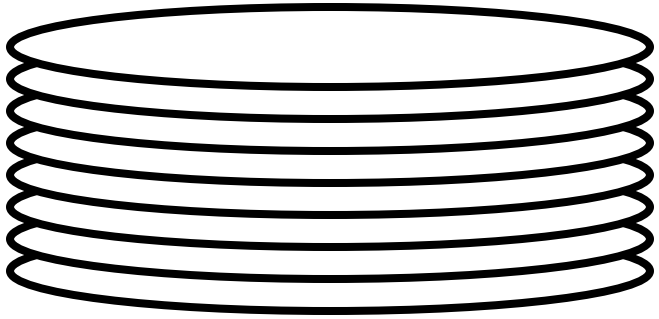
- The Accumulator (AC) register is general purpose processing register.
- Some processor unit separate one register from all others and call it an Accumulator Register.
- This register is also called as AC or A register.
- The name of this register is derived from the arithmetic addition process.
- The accumulator register is a multi purpose register capable of performing not only add micro operation but many other micro operation as well.

❑ Accumulator Register :



❑ Stack Organization :

- A **stack** can be considered as a storage method in which items are stored in consecutive memory locations and the last element stored is the first element retrieved.
- Also called LIFO (Last In First Out) list. When you want to place a new plate you will take out the topmost plate first. That is the plate last kept is the first taken out or Last in First Out.



❑ Stack Organization :

- There are two operation can be carry out by stack.

  1) PUSH

  2) POP

- The process of inserting an item into the stack is known as PUSH and is done by incrementing the stack pointer.
- The process of removing an element from the stack is called POP and is done by decrementing the stack pointer.

❑ Memory Stack :

- A stack can exist as a stand alone or can be implemented in a random access memory attached to a CPU.
- The implementation of a stack in the CPU is done by assigning a portion of memory to a stack operation and using a processor register as stack pointer.
- A portion of computer memory partitioned into three segments : program, data and stack.

❑ Polish notation :

- Evaluating ordinary arithmetic expression using a computer is difficult, particularly when an expression consists of parentheses and brackets.
- In this case expression has to be scanned from left to right.
- These problem arise because in an ordinary arithmetic expression operator is placed between the two operands, such type of ordinary expression is called ***infix*** expression.
- The polish mathematician Jan Fukasiewicz showed that arithmetic expression can be represented in ***prefix*** notation.

❑ Polish notation :

- The representation often referred to as polish notation, places operator before the operands.
- The postfix notation, referred to as Reverse Polish Notation (RPN), place the operator after the operands.
- For Example :

A + B	Infix (between)
+AB	Prefix or Polish notation
AB+	Postfix or RPN

❑ Polish notation :

Infix	Prefix or Polish Notation	Postfix or RPN
A	A	A
A+B	+AB	AB+
A-B	-AB	AB-
A+B+C	++ABC	AB+C+
A+B*C	+A*BC	ABC*+
M+(A*B)	+M*AB	MAB*+
M+(A+B)*C	+M*+ABC	MAB+C*+
(A+B)/(C-D)	/+AB-CD	AB+CD-/
A*B+C*D	+*AB*CD	AB*CD*+
A-B+C	-A+BC	ABC+-
(A+B)*C	*+ABC	AB+C*

❑ Interrupts :

- The interrupt is usually initiated by an internal or external signal rather than from the execution of an instruction.
- The address of the interrupt **service** program is determine by the hardware rather than from the address field of an instruction.
- An interrupt procedure usually stores all the information necessary to define the state of the cpu rather than storing only the program counter.

❑ Types of Interrupt :

- There are three types of interrupts that cause a break in normal execution of program.
  - (1) External Interrupts
  - (2) Internal Interrupts
  - (3) Software Interrupts

(1) External Interrupts

- The external interrupt caused by external events, they come from output devices, timing devices or power supply or any other external sources.
- The interrupt is initiated from signal that occurs in the hardware of he CPU, so they are known as Hardware Interrupt.

❑ Types of Interrupt :

(2) Internal Interrupts

- The internal interrupt is initiated by some exceptional condition caused by the program itself.
- This type of interrupts arise from illegal or erroneous use of an instruction or data, which is known as Traps.
- Internal interrupt generated due to register overflow, stack overflow, attempt to divide by zero and invalid operation code.

❑ Types of Interrupt :

(3) Software Interrupts

- Software interrupt initiated by executing an instruction.
- The most common use of this interrupt is associated with supervisor call instruction.

❑ Micro Operation :

- The operation performed on data stored in registers are called micro operation.
- Computer instructions such as ADD, AND, OR etc. are used for performing various operations.
- Each operations need execution of several micro operation.
- For Example : execution ADD operation requires execution of following micro operations.

DR ⟵ MR // fetch operand stored from memory into Data Register.

AC ⟵ AC + DR // Store the value in AC (Accumulator).

❑ Micro Operation :

- A control word of 14 bits is needed to specify a micro operation in the CPU.
- For example : the subtraction given below.
- R2 ⟵ R3 - R4.
- Specifies R3 for the A input of the ALU, R4 for the B input of ALU, R2 for the destination register, and an ALU operation to subtract A-B