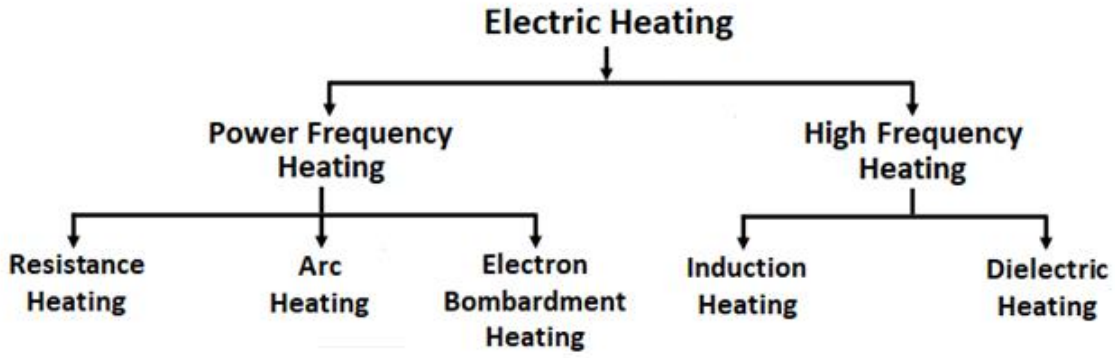
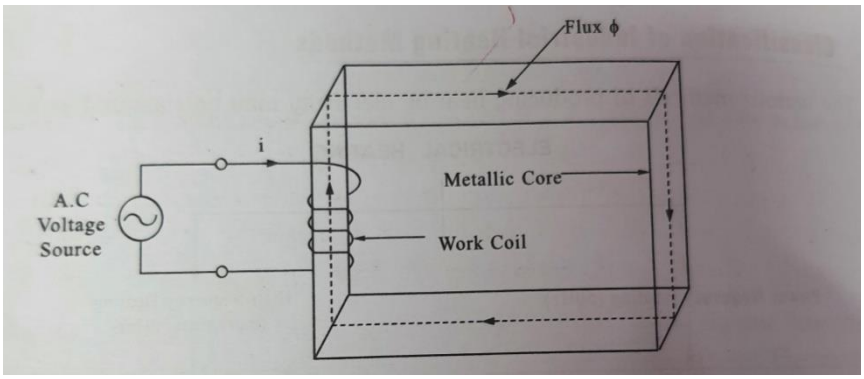
UNIT- IV
Industrial Heating and Control Systems

1. Classify different industrial heating methods.



2. Explain working principle of induction heating.

In this method the Eddy current loss can be used to heat the metal piece. Induction heating is works on the principle of transformer i.e Electro-Magnetic Induction.



Principle of Working:

1. An a.c voltage source is applied across the coil having N-turns causes a current of i-amperes flows through coil.
2. This a.c current (i) produces an a.c. magnetic flux ¢ in the core.
3. Considering the closed magnetic path in the metal core, the passage of magnetic flux results in an induced voltage 'e' in the coil according to faraday's law and is given by

$$E = -\frac{N\,d\phi}{dt}\ volt$$
$$= -L\frac{di}{dt}\ volt$$

This EMF will causes to flow of current through the core. This current is called "Eddy Current".

Eddy current loss is $\alpha\ B^2 \times f^2$

Where, B= maximum flux density in Wb/m^2,

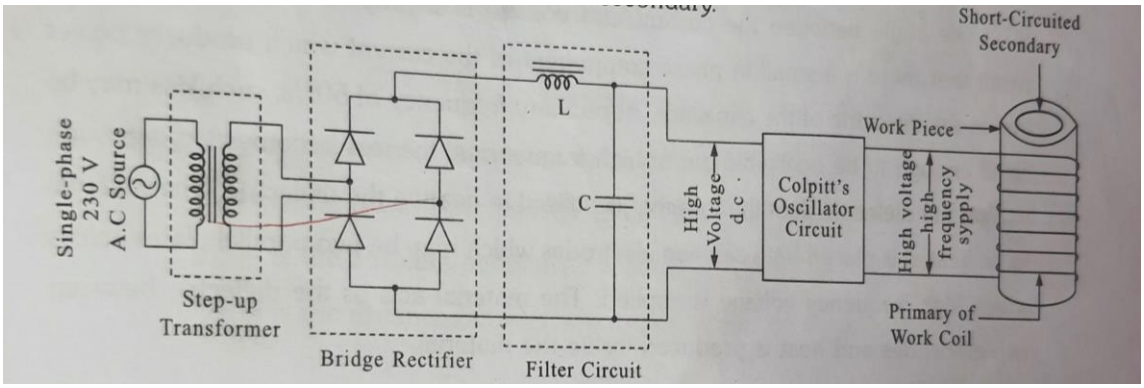
f= Frequency in Hz

If the metallic core is a Ferro magnetic material, then the material is heated by both eddy current loss and Hysteresis loss. Because the material is magnetised, demagnetised and again magnetized the molecules in the magnetic material gets repeated orientation due to this a friction developed between molecules and finally heat will be resulted. hysteresis losses and is given by $\alpha\ B \times f$

3. List the applications of induction heating?

1. Soldering or brazing of copper.
2. Melting of metals.
3. Welding.
4. Surface hardening of steel.
5. Drying of paints.
6. Annealing of brass and bronze items.
7. Forging of bolt heads and rivet heads.
8. Sterilization of surgical instruments.

4. Explain about HF power source for induction heating



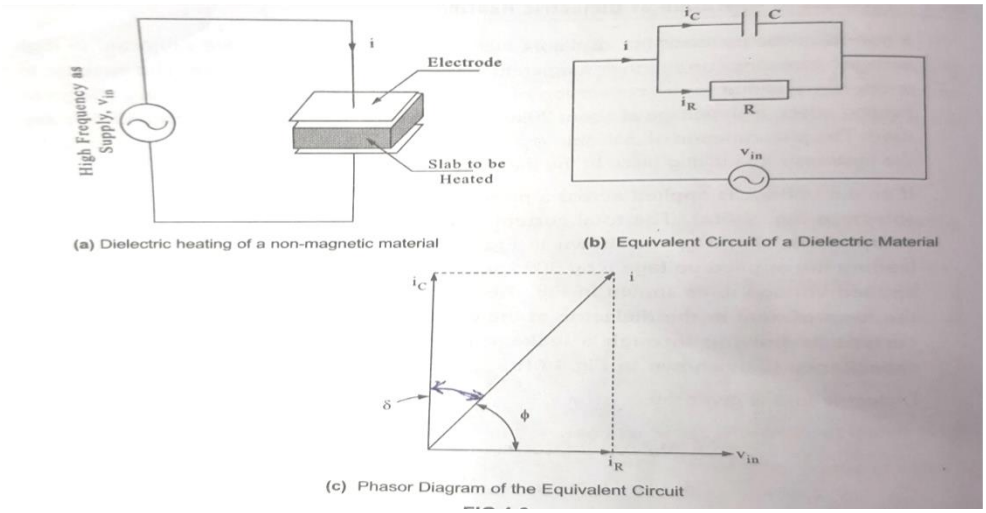
Working:

1. The 50Hz power supply input is converted into 2500V by the step up transformer. This voltage rectified by a bridge rectifier.
2. The ripple components are reduced by the use of an LC filter.
3. This ripple -free high voltage dc is fed to a colpitt's oscillator. The oscillator circuit produces high frequency power.
4. This high frequency power given to the input of an inductive coil which is the primary of the work coil.
5. The work piece acts like a short - circuited secondary.
6. The oscillator circuit produces a high frequency - high voltage supply which leads to a large amount of heat loss.
7. To minimise the heat loss, the system has to be designed properly for absorbing the heat within the oscillator circuit. The induction coils are made in the form of hollow tubes through which cold water is circulated to absorb heat. The frequency used in the case of non-magnetic materials is about 50 KHz.

5. Explain the principle of operation of Dielectric heating.

1. Dielectric heating also called as high frequency capacitance heating, is used for heating non-metals like wood, plastic etc.
2. Dielectric heating operates on the principle that when a capacitor is placed in an electric field, its molecules are subjected to stress and are disturbed. The current drawn by it is never leading the voltage by exactly 90°.
3. The angle between the current and voltage is slightly less than 90°, with the result that there is a small in phase component of the current which produces power loss in the dielectric of the capacitor.
4. At ordinary frequency of 50Hz, such loss may be small enough to be negligible but at high frequencies, the loss becomes large enough to heat the dielectric.

5. It is the loss that is utilised in heating the dielectric. The material to be heated is placed between two electrodes which may be two parallel plates across which high frequency voltage is applied. The material acts as the dielectric between two electrodes and heat is produced inside the material.
6. Where i_c is the capacitive current leading the applied voltage V by 90°. i_r is the resistive current in phase with the applied voltage V, The resulting dielectric loss appears in the form of heat in the dielectric of the capacitor.



(a) Dielectric heating of a non-magnetic material

(b) Equivalent Circuit of a Dielectric Material

(c) Phasor Diagram of the Equivalent Circuit

Dielectric loss is given by, P= VI cos**ϕ**

Then P = VI_R, (cos**ϕ** = $\frac{I_R}{I}$)

P = V I_C tanδ ($\frac{I_R}{I_C}$ = tanδ)

P= V. $\frac{V}{X_C}$ tanδ

P= V^2 2πfC tanδ ($X_C = \frac{1}{2\pi fC}$)

Where C = capacitance of the parallel plate capacitor

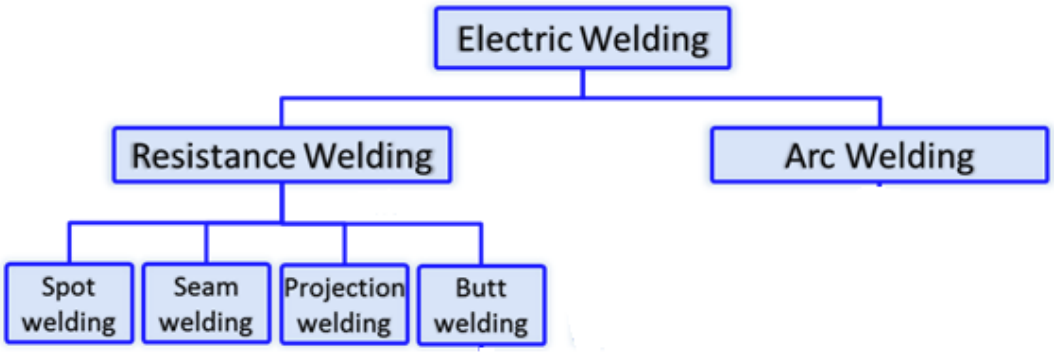
$$C = \frac{\epsilon_0 \epsilon_r A}{d}$$

The dielectric loss is proportional to,
(i) Frequency.
(ii) Square of the applied voltage, and
(iii) Capacity of the charge.

6. Write the applications of dielectric heating.

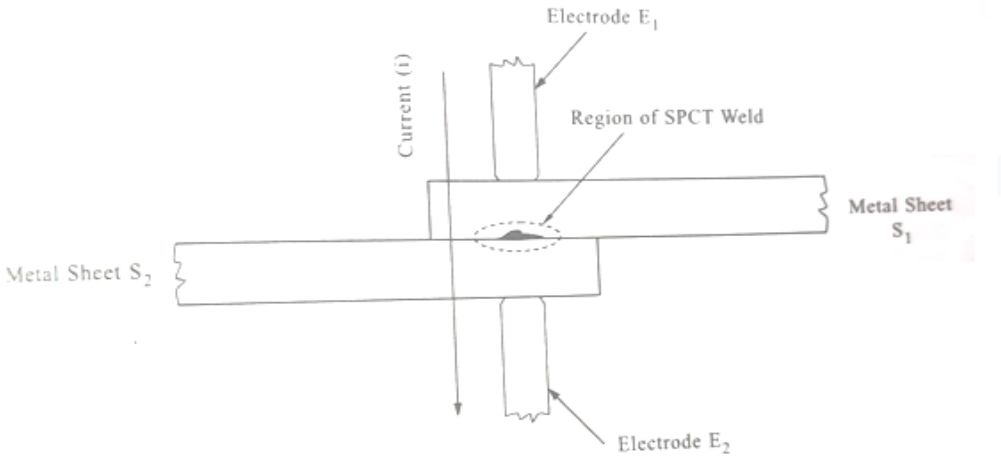
1. Preheating and curing of plastics.
2. Gluing drying and curing of wood.
3. Food processing.
4. Sewing of plastic films.
5. Curing of resin adhesives in
6. In textile industry for heat treatment of nylon, terylene etc.
7. Processing of chemicals during manufacture.
8. Processing of rubber and synthetic materials.
9. Processing and manufacturing of semi conductor devices.

7. List the different types of electrical welding



8. Explain the principle of resistance welding.

1. Electric Resistance welding is the process of fusing two or more metal pieces together by ac or dc current of high value that flows for a short duration through the area of contact.
2. The duration of the current is varied from a few milliseconds to several seconds depending upon the job requirement.
3. The heat required for the purpose of the weld is produced by the resistance offered to the flow of the current at the junction of two metals.
4. In which two metallic pieces to be welded together are pressed against each other by two electrodes of Resistance welding unit.
5. A high current is made to flow between two electrodes. This current while flowing through metallic plates produces large heat due to I^2R loss. Where R is contact resistance between the metal plates.



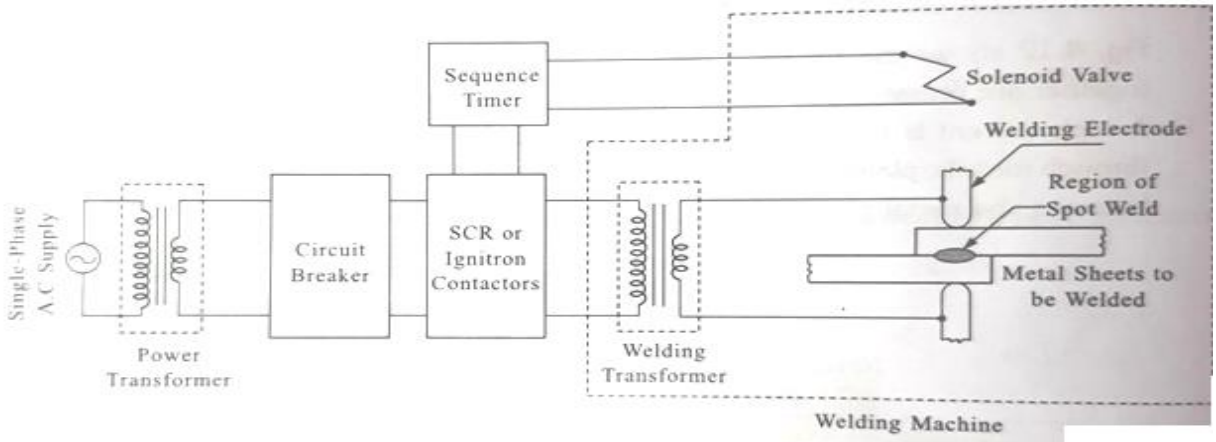
6. As a result localised melting occurs and two pieces are fused together at that point. Now the current is stopped but the pressure is still retained.
7. As there is no heating effect now, the fused portions cool down and get welded to each other. After this the pressure is removed and next weld begins. This is the basic principle of resistance welding.

9. List the applications of resistance welding.

1. Used for fabricating pressure tight & leak proof tanks.
2. Exhaust systems.
3. Used for welding rail ends.
4. Used for welding rolled sections.

5. Used for shaft axles.
6. Used for welding Rods, pipes and wires.
7. Used for production works.
8. Used for making lap and butt joints.

10. Explain the basic circuit of AC resistance welding and its working.



Block Representation of an Arc Resistance Welding Scheme

- In this, the welding machine receives ac power, by means of a timing device, through a power transformer, a circuit breaker, and an SCR or ignitron contactor.
- Inside the welding machine, a welding transformer reduces the voltage at the electrode tips (1 to 10V) and supplies a large welding current, while drawing about 50 to 2000A from the ac supply.
- The electrode tips are water-cooled and must be kept clean. A solenoid valve applies air pressure to the electrodes for bringing them together and squeezing the work pieces (metal pieces) properly.
- Welding current then flows to heat the work piece and make the weld. The work piece is held under pressure for a few moments until the weld hardens.
- Then the electrodes separate so that the work-piece can be moved before the next weld is started.
- The resistance between the metal pieces decreases when they are forced together by the electrodes with greater pressure.
- To make a weld, current needs to flow for only a fraction of a second. The ignitron contactor must close and open the circuit quickly, and it does this hundreds of times each hour.
- The timings of the welding process which may be divided into squeeze time, weld time, hold time, and OFF time, are controlled by a sequence timer.
- So all these events are measured in a sequence. For greater accuracies, now a days electronic circuits are being used for this purpose.
- The ignition line contactor sometimes is electronically controlled to close its circuit at precise time interval.

11. Classify the different types of control systems.

The control system in general be classified in the following manner.

1. Depending on the change of state in the system,
   (a)Dynamic System: It has always a change of state
   (b) System : It has lasting steady state to fixed input

2. Static number of inputs control system is classified as follows.
   (a)Single Input and Single Output System: SISO System
   (b) Input and Multiple Output System : MIMO System

3. Depending on the type of operation.
   (a)Linear system
   (b)Non linear system
   (c)Continuous systems
   (d)Discontinuous system
   (e)Time varient system
   (f)Time invarient system

4. Depending on the Type of Parameters
   (a) Lumped parameter systems
   (b) Distributed parameter systems

5. Depending on the Type of Control
   (a)Open loop control
   (b)Closed loop control
   (c)Manually controlled system
   (d)Automatic controlled system

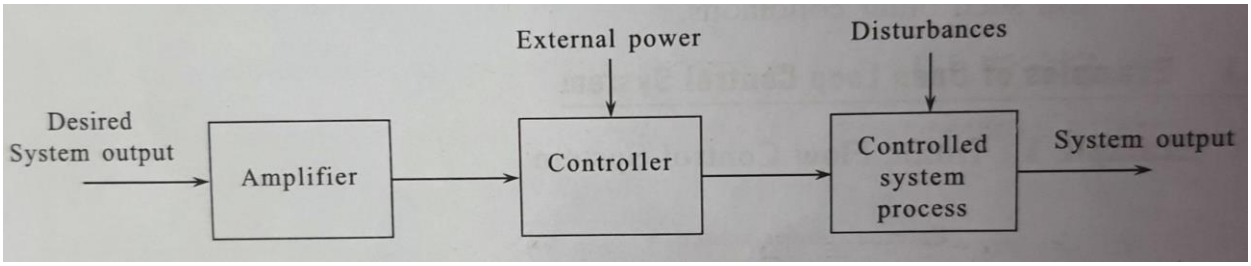
12. Define system, control system.

System: A system is a collection of matter, parts or components which are included inside a specific boundary. This boundary is the separation of the system with surrounding systems which interfere with its operation.

Control System: A Control System is a combination of elements or sub systems which tends to maintain a quantity or a set of quantities termed output suitably related to another quantity or a set of quantities termed input.

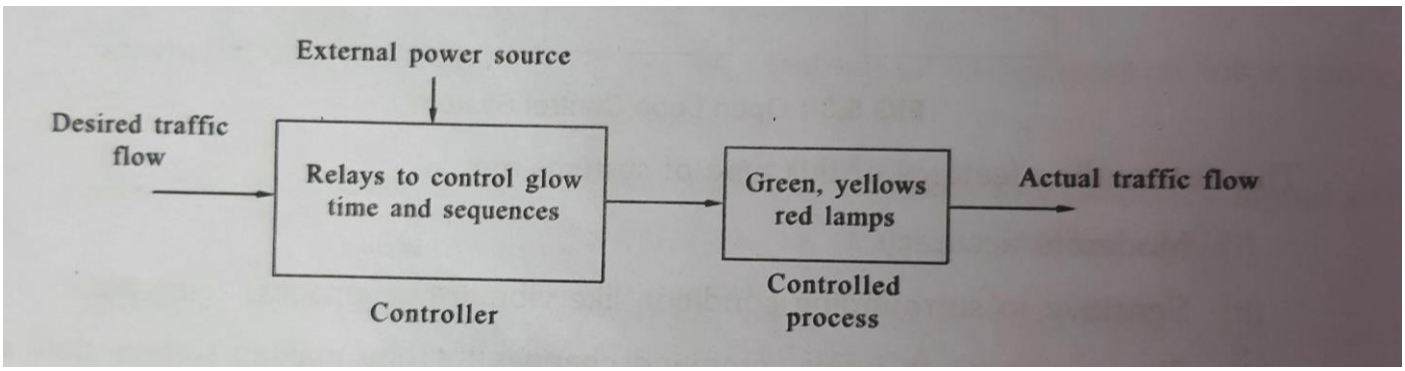
. Explain open loop control system with some examples.

1. An open loop system is that system in which the control action is independent of the system output.



2. Therefore an open loop system utilizes a controller or controlling devices to control the system process in such a way as to obtain the desired output without considering the actual system output.
3. The controller uses an external power source to have the proper control action to the controlled system process.
4. Disturbances here are environmental changes which disturb the process. Thus open loop control system is characterized by a definite relationship between desired system output and actual system output without monitoring the actual system output during normal operation of the system.

Example 1: Traffic Flow Control System

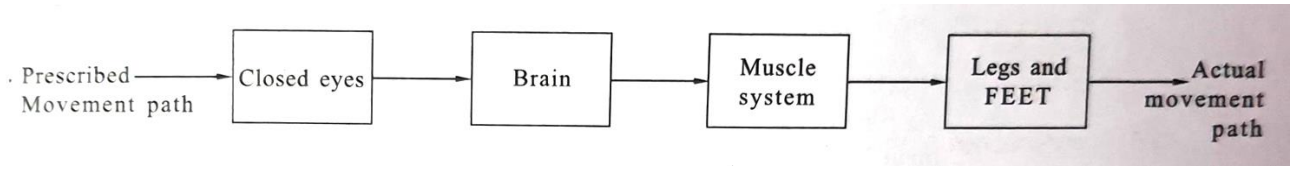


1. A traffic flow control system used on roads, to regulate the flow of traffic. In this the traffic moves when green or yellow lamp glows while stops moving when red lamp glows.
2. The traffic on the road becomes mobile or stationary depending upon the duration and sequence of lamp glow.
3. The duration and sequence is controlled by relays which are operated from an external power source. These relays are adjusted for particular values of time duration and sequence for the desired traffic flow through a calibrated dial.
4. The settings start glowing lamps in a particular Sequence with fixed time interval there by making traffic stationary or moving.
5. Sequence and time duration are not influenced by the actual flow of traffic i.e ., duration of green lamp can neither be increased when large traffic is present on the road nor can be reduced when there is no traffic on the road.

Example 2 : Biological Control System

1. The major components of the system are eyes, brain, muscles, legs and feet. The brain senses the prescribed path through eyes when fee eyes are opened.

2. Depending upon these senses the muscle system is to move the legs and feet in particular direction when the eyes are closed and the man is asked to move on the prescribed path.
3. Due to the movement of feet the man starts walking, generating the actual path of movement.
4. As the eyes are closed, the actual movement path cannot be seen and sensed by brain hence the actual movement path has no effect on the prescribed path, thereby making input independent of output and the system becomes an open loop system.



13. Write the merits and demerits of open loop control system.

Merits of Open Loop Control System

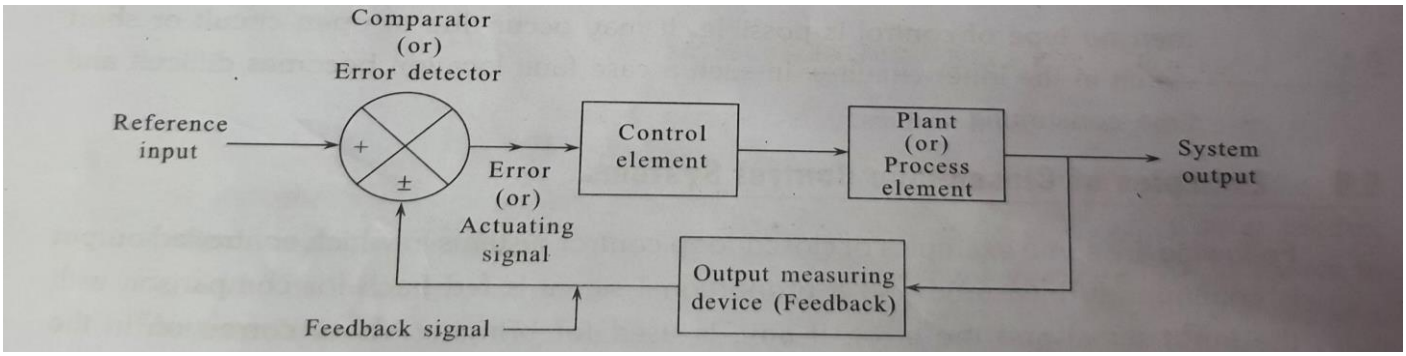
1. It is the simplest
2. Most economical type of control system
3. These systems are not expensive
4. Maintenance of the equipment is not difficult because complicated electronic circuitry is not involved

Demerits of Open Loop Control System:

1. These are usually inaccurate and unreliable
2. These systems do not adapt to variations in environmental conditions or external disturbances.
3. Because they are manually controlled, these systems are very slow in process.
4. Optimization in control is not possible in this system.

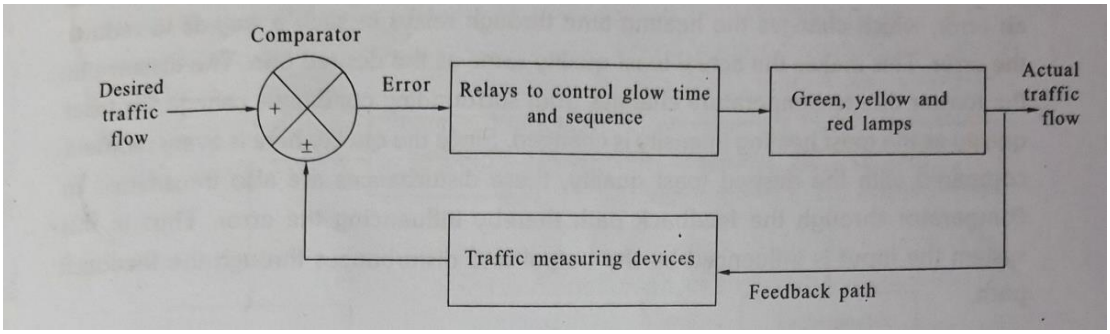
14. Explain closed loop control system with some examples

A closed loop control system is that system in which the control action is some how dependent upon the system output. Thus a closed loop control system measures the actual system output, compares it with the input and determines the error which is then used for controlling the system output to have the desired value. The closed loop sequence of operations in the system are measurement of output, comparison with reference input and calculation of error, actuation of controller and controlling the system process.



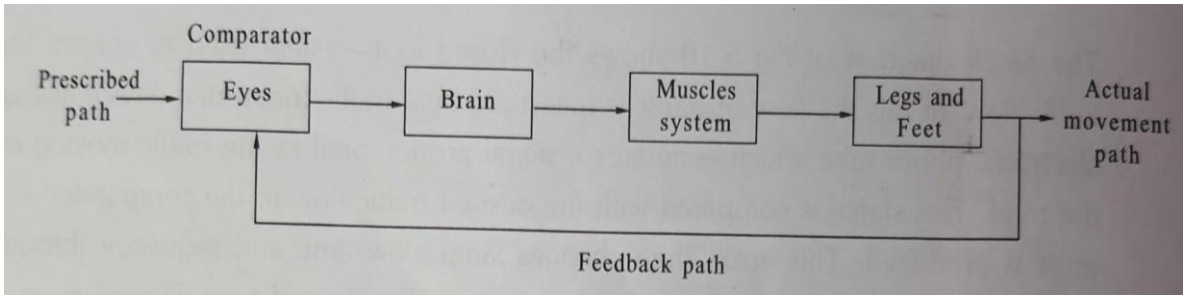
Example 1: Traffic Flow Control

1. In this the flow of traffic is measured by a traffic measuring device like an electronic photo tube which generates a signal proportional to the traffic moving on the road. This signal is compared with the desired traffic flow in the comparator and error is produced.
2. This error, then changes lamp glow time and sequence through relays. So as to bring the actual traffic flow same as the desired flow.
3. The jamming of traffic on the road will at once influence the system input through traffic measuring device because at every instant the information regarding the flow of traffic is sent to the input through the feedback path.



4. Hence the system is also sensitive to output disturbances. System is a closed loop system as the input is influenced by output through the feedback path.

Example 2: Biological System



1. In the closed loop biological system which operates when a man moves on a prescribed path with his eyes opened. The path of actual movement is compared with the prescribed path in the eyes and error is detected.
2. The error is transmitted to the brain which senses the error and operates the muscle system in such a way so that legs and feet move on the prescribed path.
3. Thus every instant the system output (actual movement of feet) is compared with the input (desired movement) through eyes thereby creating a feedback path between output and input.

15. Write the merits and demerits of open loop control system.

Merits of closed Loop Control System

1. High accuracy
2. Fast response
3. Independent to operating conditions.
4. Flexibility.

Demerits of closed Loop Control System

1. More expensive than simple man operated systems
2. Maintenance is difficult as it involves complicated electronics.
3. Installation and adjustment is very complicated.
4. If there is any fault in the instrument itself which leads to a faulty error signal then no type of control is possible. It may occur due to open circuit or short circuit in the inner circuitry. In-such a case fault location becomes difficult and time consuming.

16. Define transfer function.

The transfer function of a linear, time-invariant, differential equation system is defined as the ratio of the Laplace Transform of the output to the Laplace Transform of the input under the assumption that all initial conditions are zero.

$$\text{Transfer function} = G(s) = \frac{L(output)}{L(input)}$$

17. Compare open loop and closed loop control system.

S.No.	Open Loop	Closed Loop
1.	In an open loop control system the control action is independent of the output	In an closed loop control system the control action is independent of the output.
2.	This system is very simple.	This system is complex.
3.	Its cost is low	Its cost is more
4.	It is more stable	Less stable
5.	Moderate accuracy	High accuracy
6.	Slow response to the input signal.	Fast response to the input signal
7.	It does not give automatic correction for any external disturbance	It gives automatic correction for external disturbances
8.	It is dependent upon the operating condition	It is independent operating condition