Disadvantages

- more expensive than manually operated machines

- The CNC machine operator only needs basic training and skills, enough to supervise several machines. In years gone by, engineers needed years of training to operate centre lathes, milling machines and other manually operated machines. This means many of the old skills are been lost.

- Investment in CNC machines can lead to unemployment

i. Costly setup, skilled operators
ii. Computers, programming knowledge required
iii. Maintenance is difficult

CLASSIFICATION OF NC MACHINES

In present era, variety, complexity of geometry, tolerances, skill of personnel and availability of funds by considering all factors, the NC machines are designed according to meet different requirements within the cost constraints. These machines are broadly classified as the following :

(a) Based on feedback control, and (b) Based on control system features.

A control System is a device, or set of devices to manage, command, direct or regulate the behaviour of other device(s) or system(s).

System – An interconnection of elements and devices for a desired purpose.

Control System – An interconnection of components forming a system configuration that will provide a desired response.

BASED ON FEEDBACK CONTROL

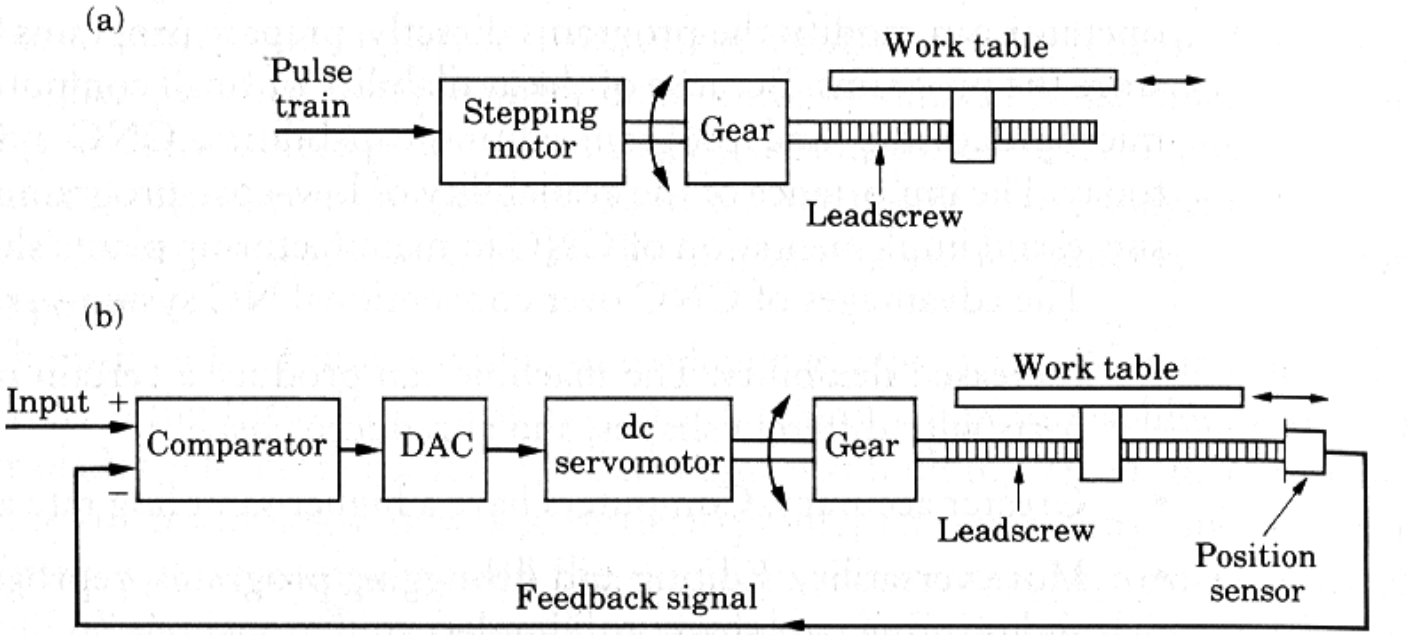
In the NC machines, to control the position of a machine slide, a group of electromechanical, pneumatic or hydraulic components are used which are collectively known as Servo Mechanism. The output from the data handling equipment is passed through separate channels to servo system, which in turn drives the machine slides. This servo system, based on feedback control, can be approached in some ways :

FEEDBACK DEVICES

The NC machine tools generally are run with a closed loop control system. For this purpose it is necessary to provide appropriate feedback in order to achieve accurate control of the movement of the axes. The feedbacks that are normally used are the displacement and velocities of the individual axes in the machine tool. The typical positional sensors used in the NC machine tools are :

(a) Encoders, and (b) Linear scales.

Open loop and Closed loop controls



In open loop systems the slide may overshoot or may not reach desired position because of inertia, wear and tear and friction, hence inaccurate machining.

Open loop control system is usually appropriate when the following conditions apply: –

-The actions performed by the control system are simple.

- The actuating function is very reliable

- Reaction forces opposing the actuator are small enough to have no effect on the actuation.

Advantages
- Less expensive
- Less complicated

Disadvantages -
-Accuracy
- Repeatability
- Setup

· Open loop — control signals are given to actuators by the MCU, but the movements and final destinations of the positioning system are not checked for accuracy.
· Closed loop — equipped with transducers and sensors to measure positions, compare with control signals, and correct positions as necessary.

Examples:- Washing Machine, Toaster, Electric Fan

Closed Loop Systems

In closed loop systems the position sensors are used to correct slide movements and achieve higher accuracy and repeatability. **Closed-Loop Control Systems** utilizes feedback to compare the actual output to the desired output response.

Main difference from an open loop system is the inclusion of a feedback system in the controller.

- Feedback may be analog or digital
- The feedback mechanism allows the machine to "know" where the tool is in regards to previous movements

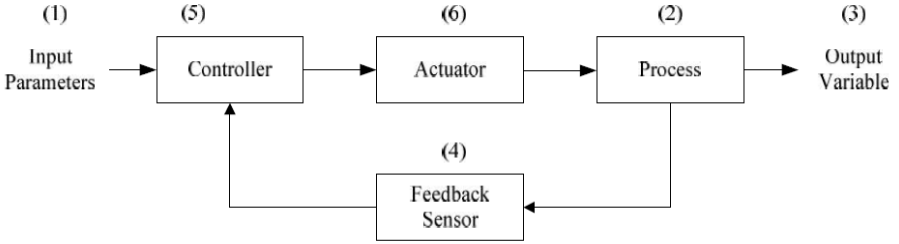


Figure 1.2 A feedback control system

Examples:- Refrigerator, Iron

FEEDBACK DEVICES

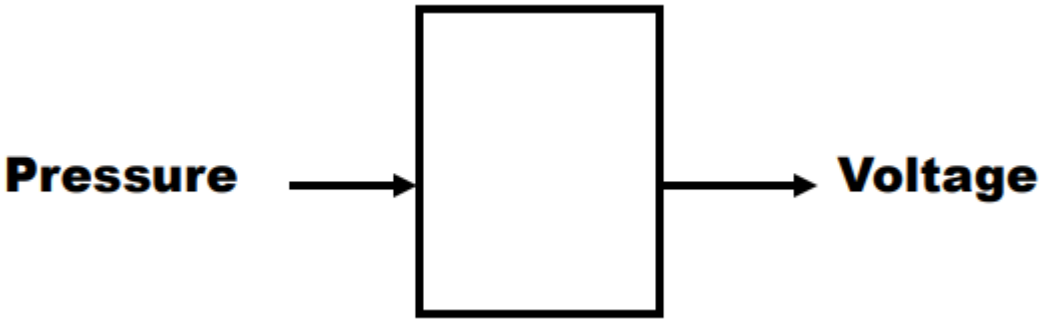
The output of a system that is *returned* to modify the input.

Transducer or Sensor Factors

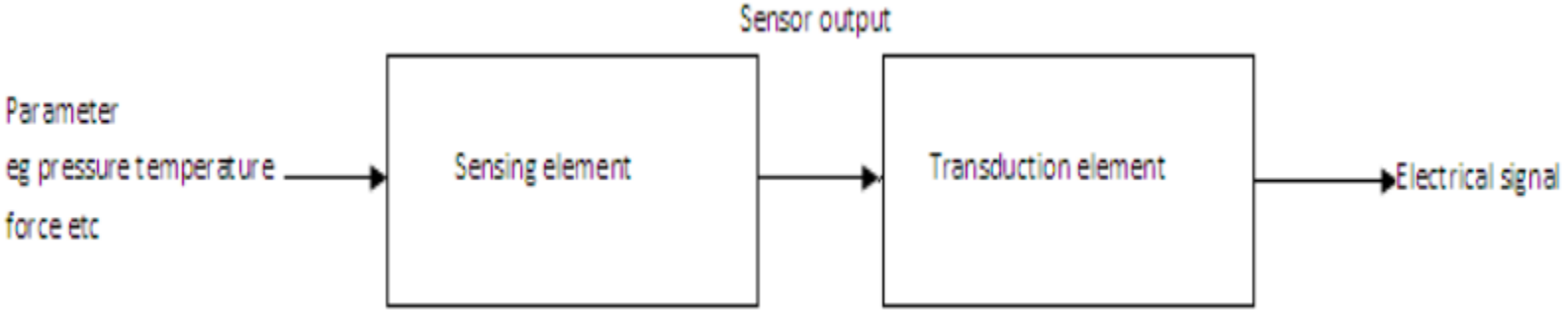
- Accuracy
  - Absolute values - the state of the environment
  - Relative values - the change of state of the environment
- Repeatability / reliable - always gives the same reading given the same circumstance.
- Interchangeabilty requires high accuracy
- Long term stability / resistance to environment
- Most all transducers have a non-linear relationship between input and output.
- Size and cost

A transducer is a device that convert one form of energy to other form. It converts the measurand to a usable electrical signal.

In other word it is a device that is capable of converting the physical quantity into a proportional electrical quantity such as voltage or current.



- Transducer contains two parts that are closely related to each other i.e. the sensing element and transduction element.
- The sensing element is called as the sensor. It is the device producing measurable response to change in physical conditions.
- The transduction element convert the sensor output to suitable electrical form.



TRANSDUCERS SELECTION FACTORS

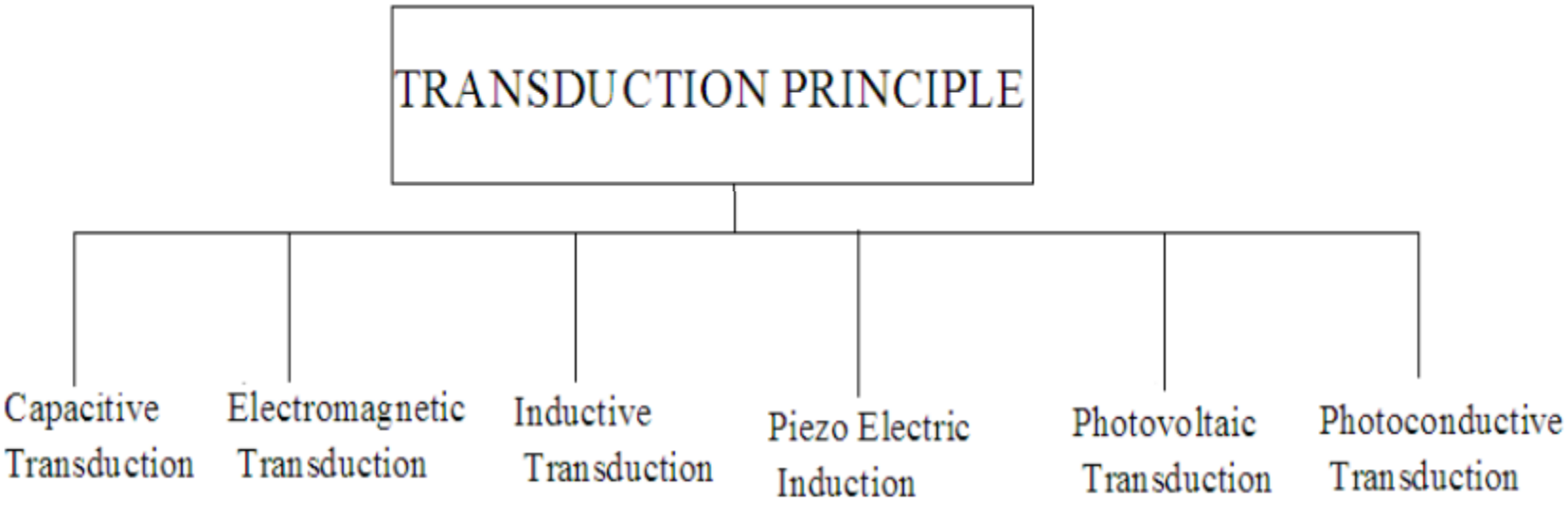
1. **Operating Principle**: The operating principle used may be resistive, inductive, capacitive , optoelectronic, piezo electric etc.
2. **Sensitivity**: The transducer must be sensitive enough to produce detectable output.
3. **Operating Range**: it should maintain the range requirement and have a good resolution over the entire range.
4. **Accuracy**: High accuracy is assured.
5. **Cross sensitivity**: There are situation where the actual quantity is being measured is in one plane and the transducer is subjected to variation in another plan.

6. Errors: it should maintain the expected inputoutput relationship as described by the transfer function so as to avoid errors.
7. Transient and frequency response : it should meet the desired time domain specification like peak overshoot, rise time, setting time and small dynamic error.
8. Loading Effects: it should have a high input impedance and low output impedance to avoid loading effects.
9. Environmental Compatibility: It should be assured that the transducer selected to work under specified environmental conditions maintains its input-output relationship and does not break down.
10. Insensitivity to unwanted signals: The transducer should be minimally sensitive to unwanted signals and highly sensitive to desired signals.

The transducers can be classified as:

I. Active and passive transducers.
II. Analog and digital transducers.
III. On the basis of transduction principle used.
IV. Primary and secondary transducer
V. Transducers and inverse transducers.

CLASSIFICATION OF TRANSDUCERS According to Transduction Principle



- **Position Feedback**
- Used when the output is a **linear distance** or **angular measurement.**
- The absolute position feedback range defines the movement over which it must be possible to uniquely determine the position.
- **velocity feedback**
- Feeds back *rate of change of position*
- Motion smoothing
- Uses a electrical/mechanical device

velocity feedback

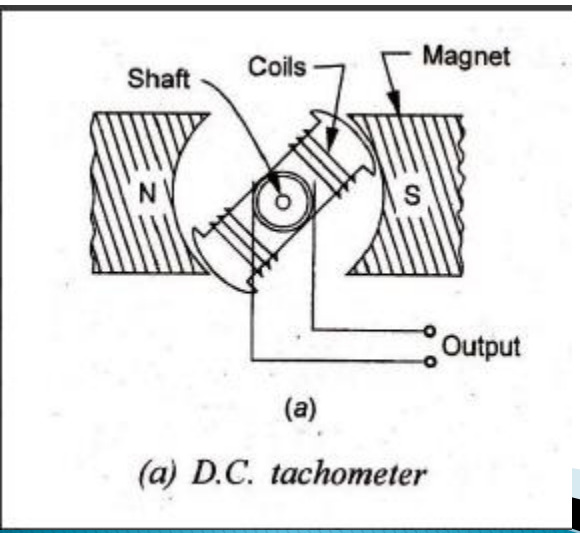
DC tacho-generators –

A DC motor is a device that converts direct current (electrical energy) into rotation of an element (mechanical energy). These motors can further be classified into brushed DC motor and brushless DC motors.

The DC tacho-generator uses the same principles of magnetic coupling as the AC tachogenerator. The DC tacho-generator, however, has a steady (non-fluctuating) primary magnetic field. This magnetic field is usually supplied by permanent magnets. The amount of voltage induced in the rotor winding is proportional to the number of magnetic flux lines cut. The polarity of the output voltage is determined by the direction in which the rotor cuts the lines of magnetic flux.

The physical construction and operation of the DC tacho-generator is very similar to a DC generator. The only difference is that the DC tacho-generator is much smaller in size and is linked mechanically to the servo motor or load instead of to a prime mover.

A DC tacho-generator outputs a DC voltage directly, whose amplitude is directly proportional to the speed of the rotating shaft.



(a) D.C. tachometer

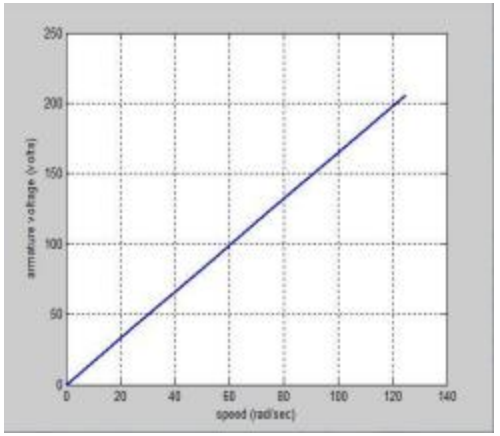
As we see in above figure (a), coil is attach with shaft and this coil can rotate in between two permanent magnets. So, when tachometer is attach with rotating shaft it rotate in between magnets and cut the magnetic field. Thus, according to Faraday's law, voltage should be produced in coil. This produced voltage is proportional to coils speed alternatively proportional to shaft speed. Voltage generated inside is calibrated in terms of RPM and hence tachometer shows RPM of shaft. In this, DC voltage is produced.

Advantages –: •

- The design of the brushed DC motor is quite simple •
- Controlling the speed of a Brush DC Motor is easy •
- Very cost effective.

Disadvantages : •

- High maintenance •
- Performance decreases with dust particles •
- Less reliable in control at lower speeds •
- The brushes wear off with usage.



➢**Positional Feedback**

Position sensors are devices that can detect the movement of an object or determine its relative position measured from an established reference point. These types of sensors can also be used to detect the presence of an object or its absence.

The primary types of position sensors include the following:

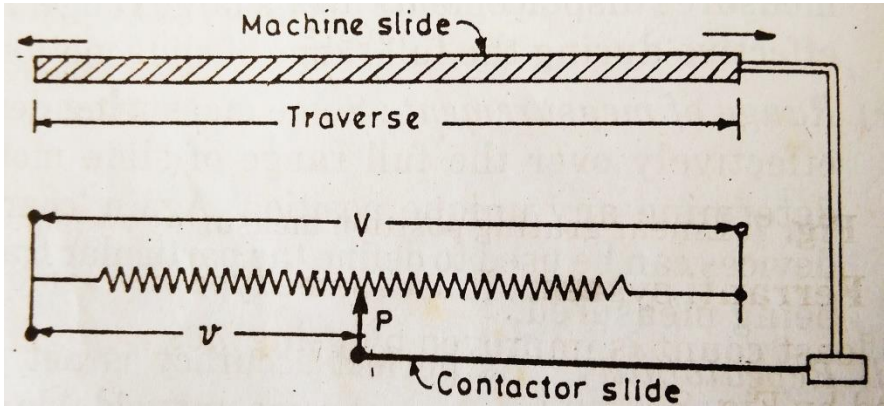
- Potentiometric Position Sensors (resistance-based)
- Inductive Position Sensors
- Eddy Current-Based Position Sensors
- Capacitive Position Sensors
- Magnetostrictive Position Sensors
- Hall Effect-Based Magnetic Position Sensors
- Fiber-Optic Position Sensors
- Optical Position Sensors
- Ultrasonic Position Sensors

Positioning Feedback Devices (Transducers)

↓

Linear Transducers	Encoders/Rotary Transducers
(*i*) Glass scales with line gritting	(*i*) Resolver
(*ii*) Ferranti System	(*ii*) Rotary encoder
(*iii*) Binary coded scale	
(*iv*) Inducto syn	

Potentiometric Position Sensors



Potentiometric Position Sensors are resistance-based sensors that use a resistive track with a wiper that is attached to the object whose position is being monitored. Movement of the object causes the wiper to change its position along the resistance track and therefore alter the measured resistance value between the wiper position and the end of the track.

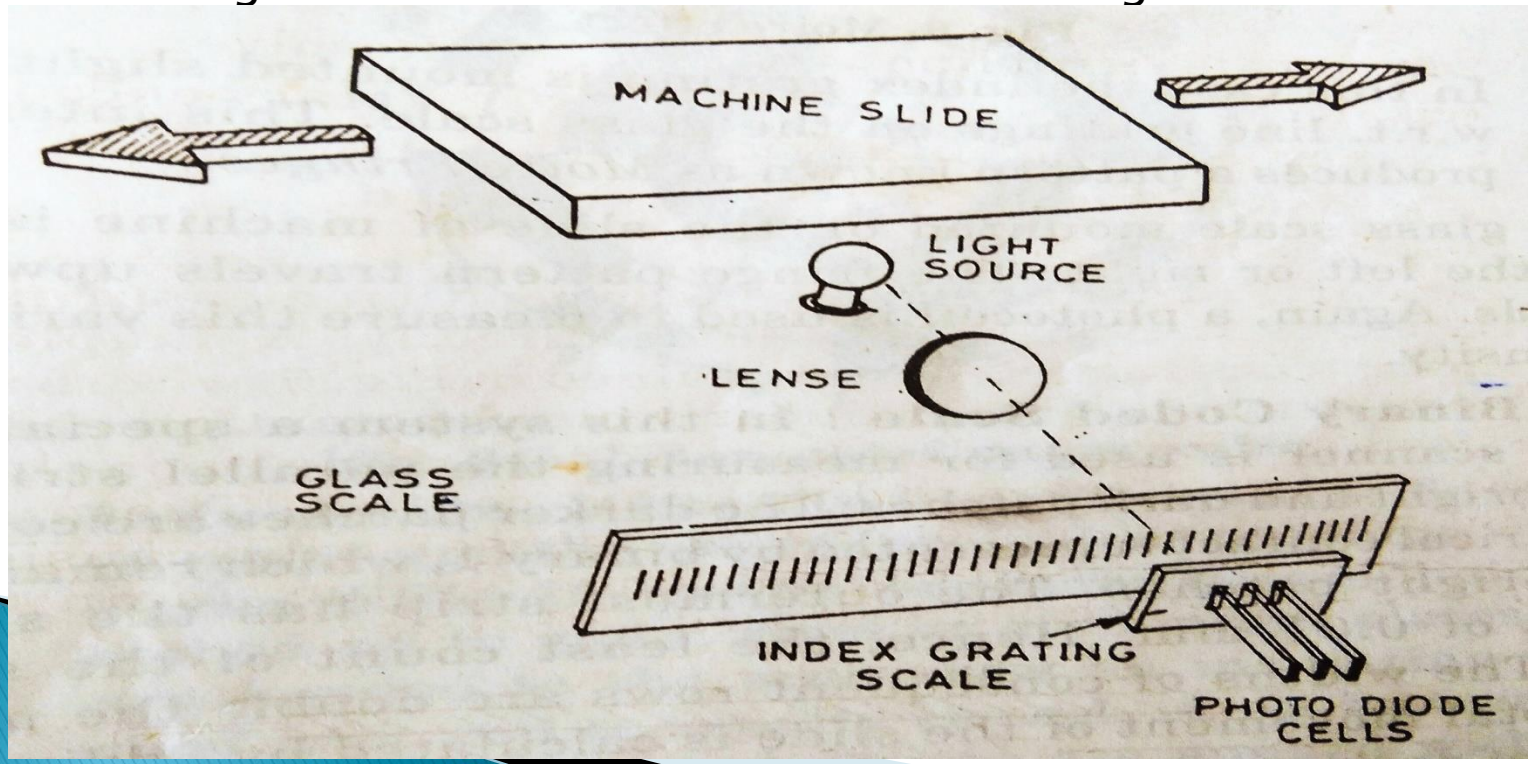
In this manner, the measured resistance can be used as an indicator of the object's position. This is accomplished by using a voltage divider where a fixed voltage is applied across the ends of the resistance track, and the measured voltage from the wiper position to one end of the track yields a value that is proportional to the wiper position. This approach works for both linear displacements and rotary displacements.

These types of position sensors offer relatively low cost, but also suffer from low accuracy and repeatability. In addition, the size limitation of the device by design constrains the range over which the positional change can be measured.

(i) Glass scale with line grating

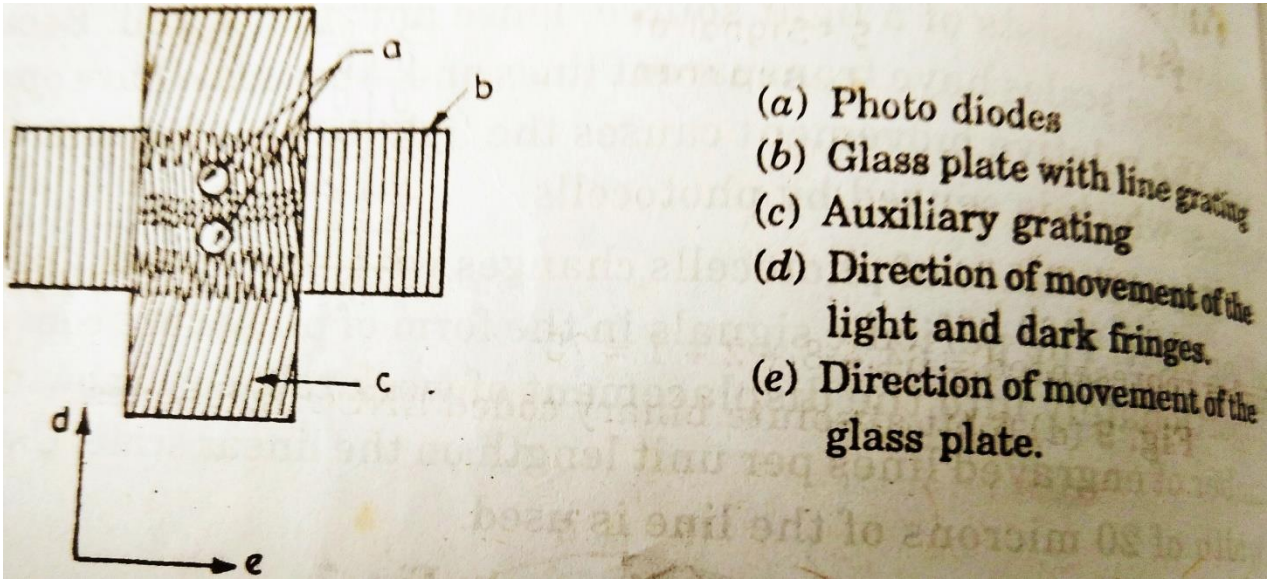
The **glass scale** is marked with very fine **lines**, referred to as **gratings** or graduations, with a **grating** period (spacing) as small as just a few microns. The scanning reticle (part of the scanning head, or read head) has **gratings** that are the same as the **scale.**

In the imaging method of scanning, an LED source passes light through the scanning reticle. When the scanning reticle and scale move relative to each other, the light is modulated. If the gaps in the gratings align, light passes through, but if the lines of the reticle coincide with the gaps of the scale (or vice-versa), no light can pass through. Photovoltaic cells monitor these fluctuations of light and convert them into electrical signals to track movement.



Ferranti system –

It uses the same type of grating scales except that the least count is improved(4micron to 1 micron) by using moire effects.



In this case the index grating is mounted slightly tilted w.r.t. line gratings on the glass scale. This interference produces a pattern known as Moire Fringes. The glass scale mounted on the slide of m/c is moved towards the left ot right. The fringe pattern travels upwards or downwards. Again, a photocell is used to measure this variation in light intensity.

3- Binary Coded Scale

4-Inducto syn

Rotary or Angular Position Measuring Transducer-

1-Resolver

2-Digital Optical Encoder