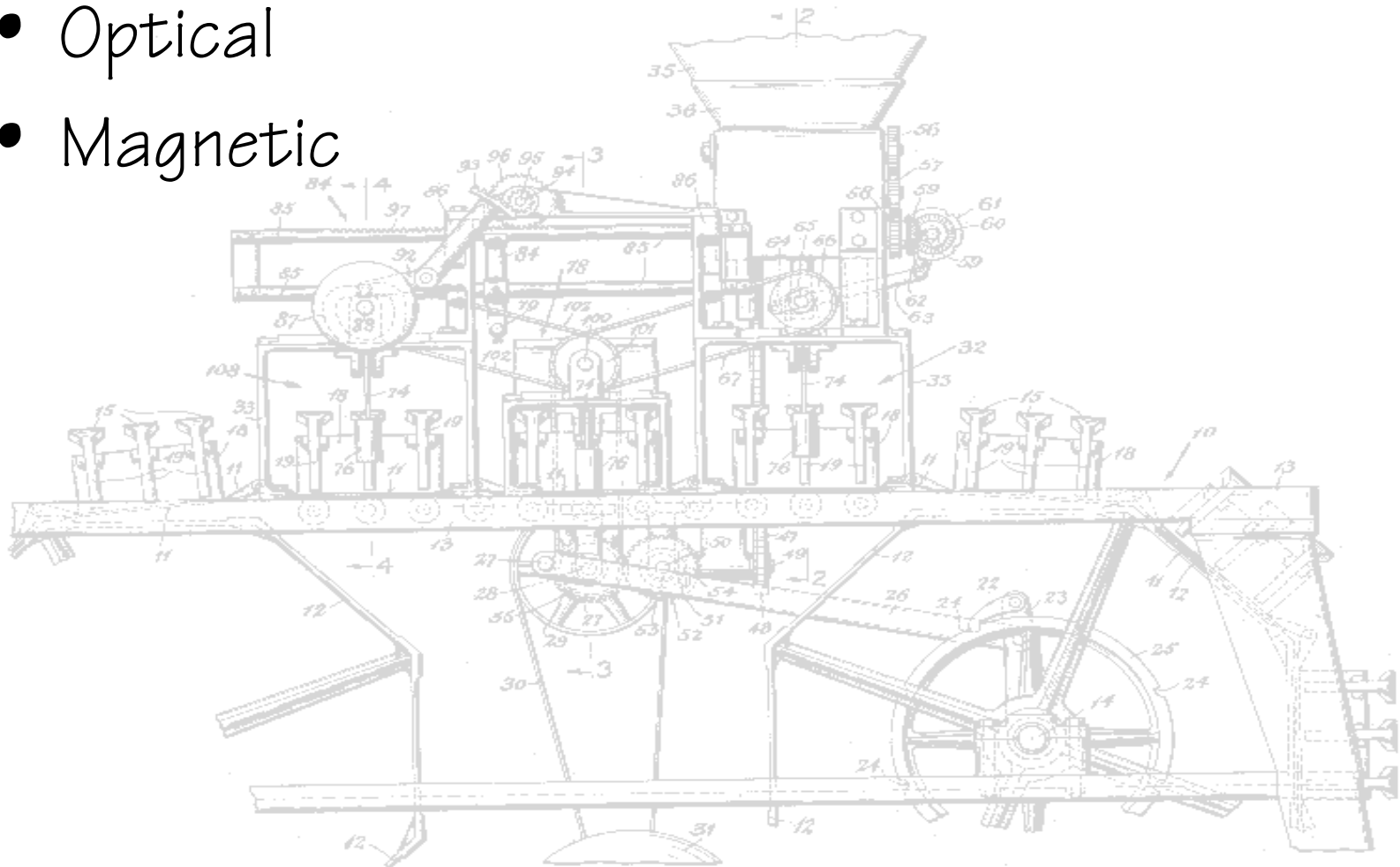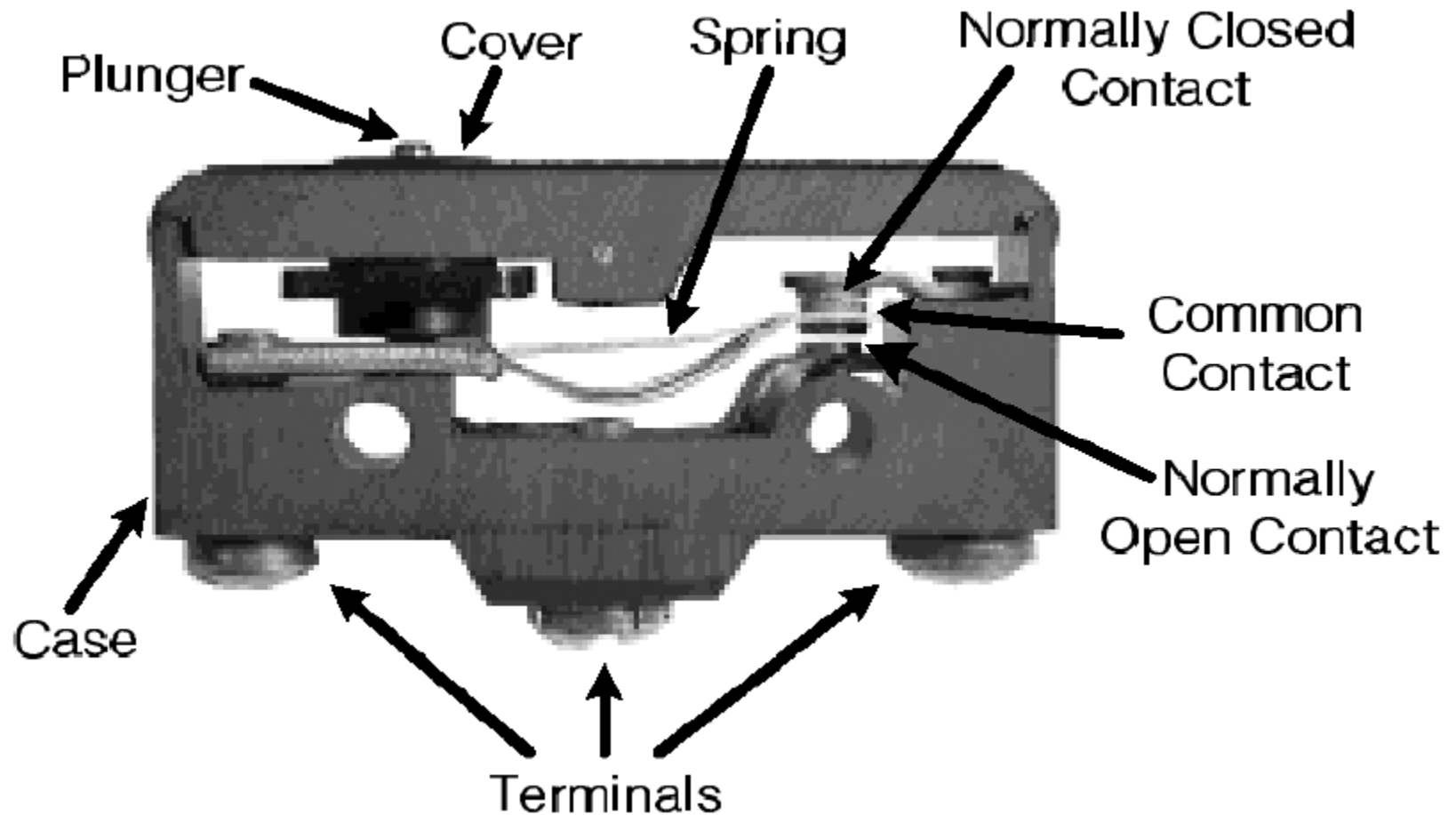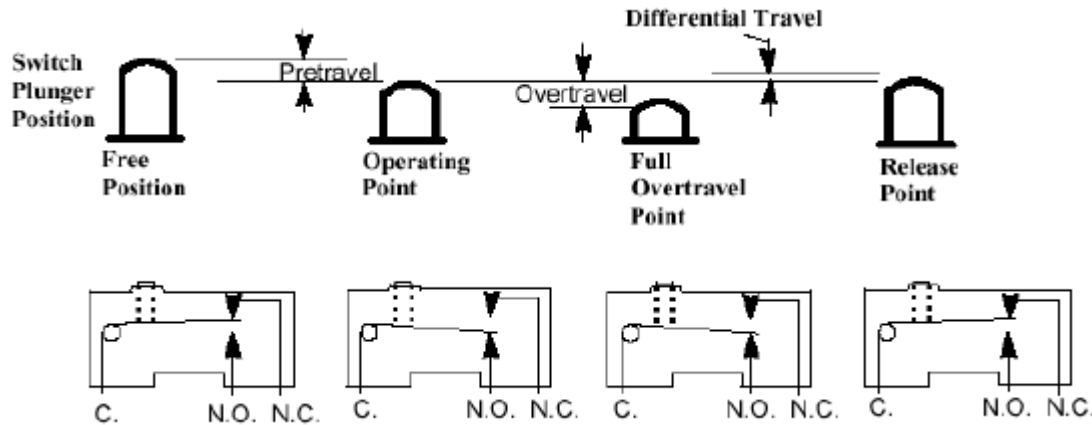# Position Sensing

- Mechanical

- Optical

- Magnetic

Mechanical Sensing - Microswitch
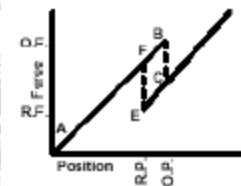
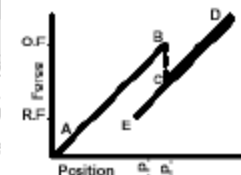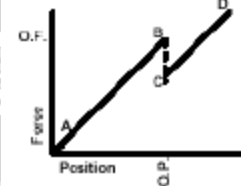# Microswitch Operation
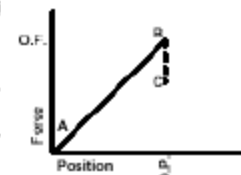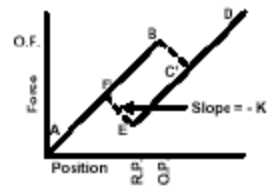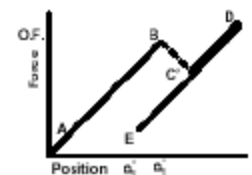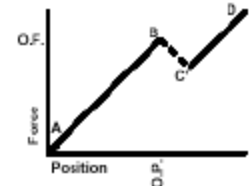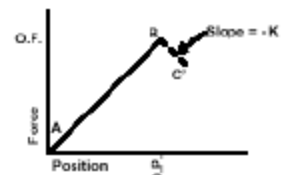
Switch exhibits mechanical hysteresis.

Microswitch Actuators

Pin plunger; in-line motion
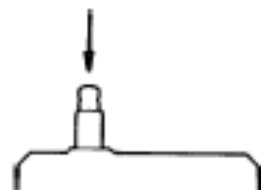
Overtravel plunger; in-line applications requiring additional overtravel

Added overtravel in a panel mount roller plunger; Actuation by cams

Leaf; Low-force, slow moving cams or slides

Roller lever; Very low force, fast moving cams

Roller leaf; Low-force, large movement actuation

Lever; Very low force, slow cams and slides
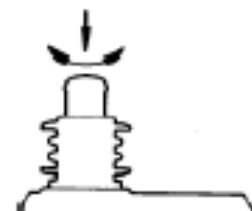
Added overtravel in a panel-mount plunger: Heavy-duty in-line applications or slow cams. Cam rise should not exceed 30°
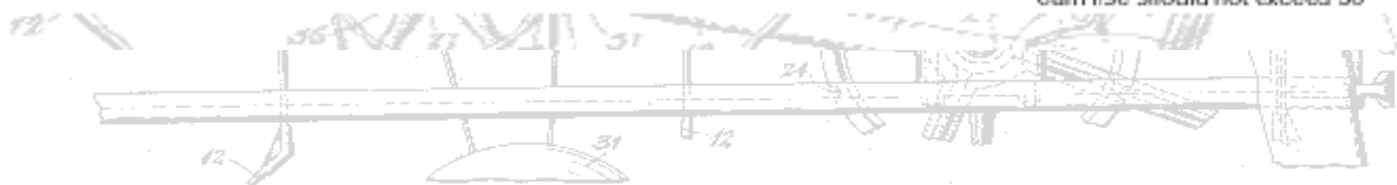
Optical Sensing

- LED's and Photodiodes

- Transmissive/Reflective

- Modulated/Unmodulated

- Light-on/Dark-on

- Fiber optic
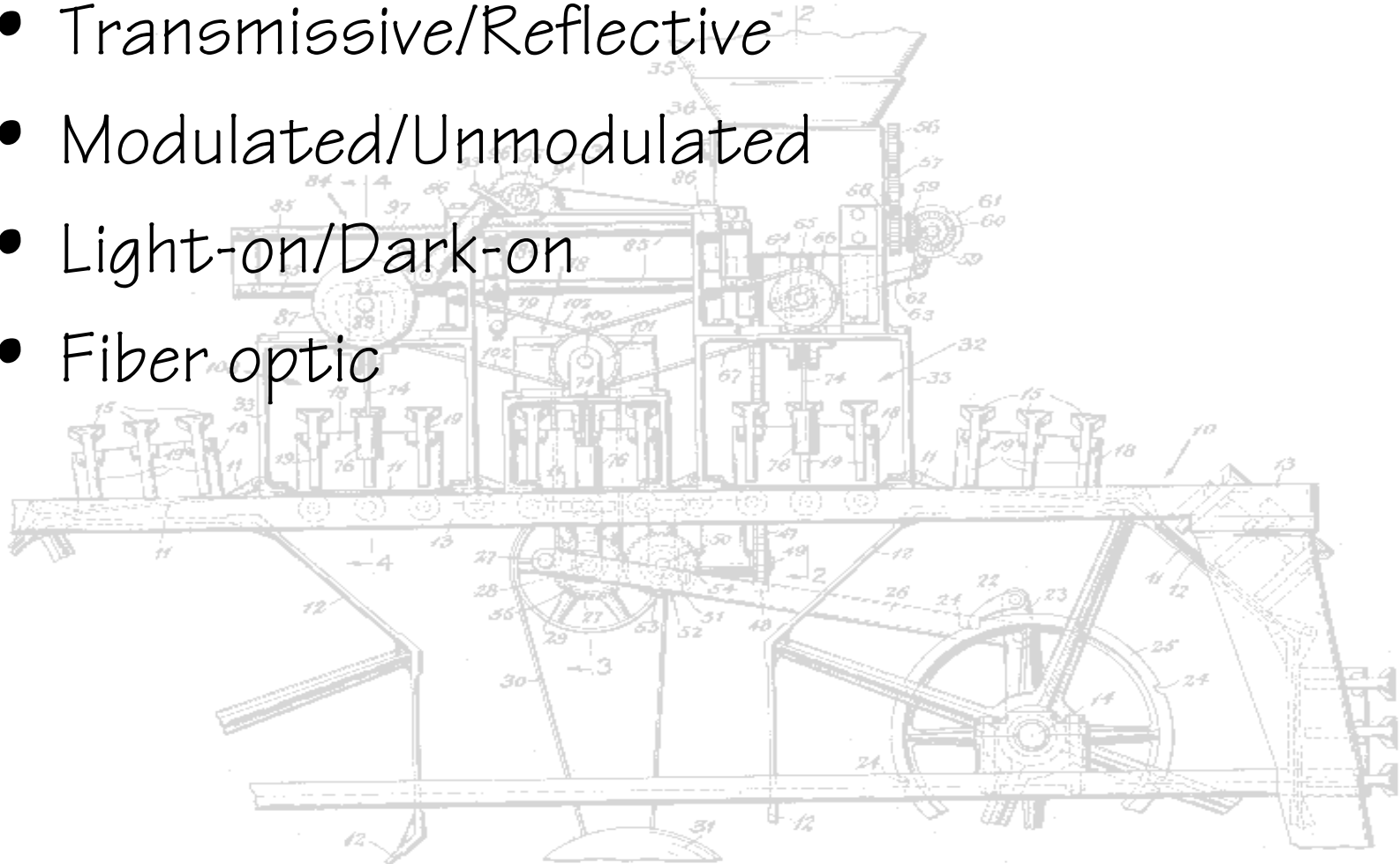
LED and Photodiode Characteristics

Wavelengths of Commonly-used Light Emitting Diodes (LEDs)

Polarized Light

Emitted light is linearly polarized

Light Source

Polarizing Filter
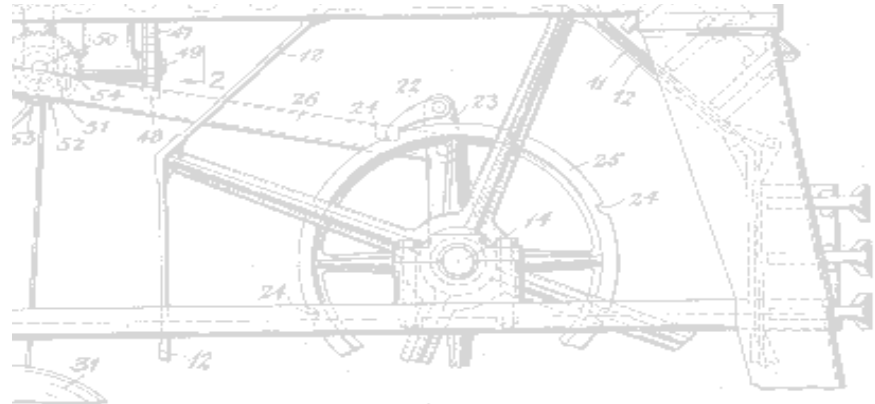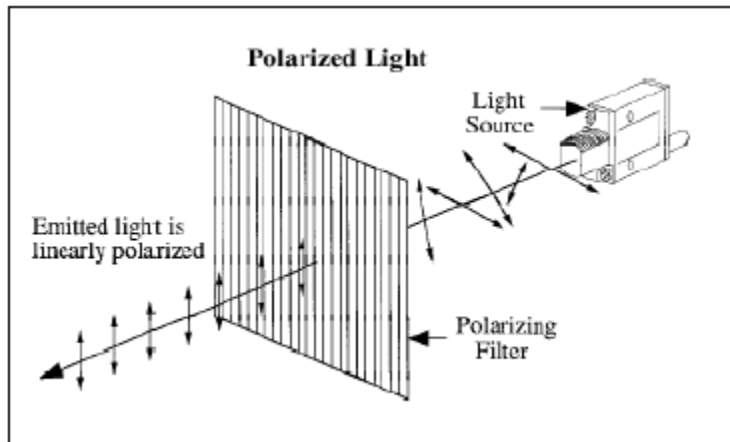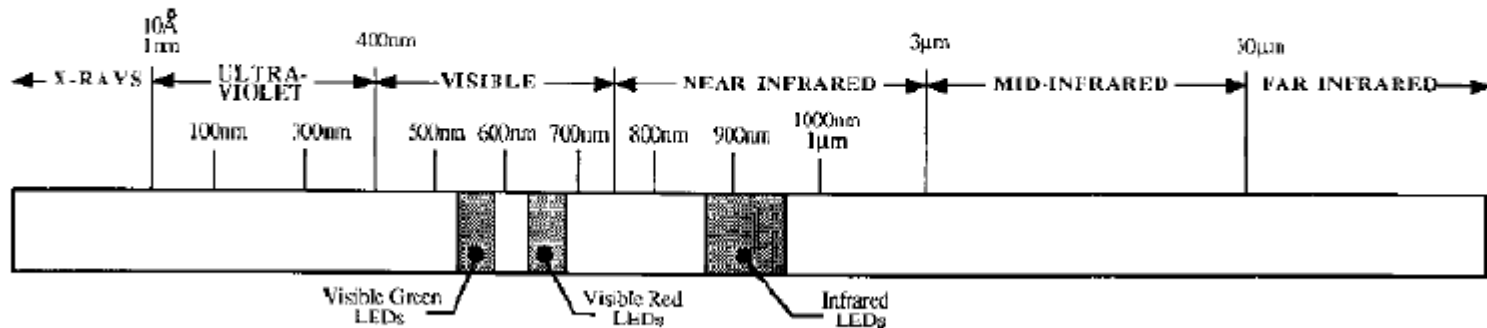
Transmissive & Reflective Sensors

Opposed Mode Alignment

Opposed Mode Alignment: Move Emitter or Receiver Up-Down, Left-Right, and Rotate
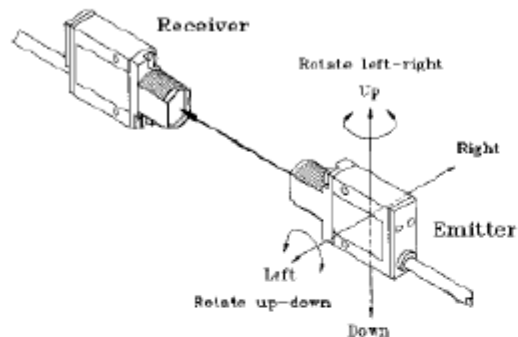
Retroreflective Mode Alignment

Retroreflective Mode Alignment: Move Target Up-Down, Left-Right
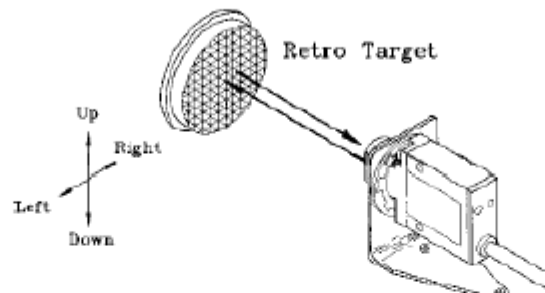
Proximity (Diffuse) Mode Alignment

Diffuse Mode Alignment: Rotate Up-Down, Left-Right

Divergent Sensing Mode

Fixed-field Diffuse Sensing
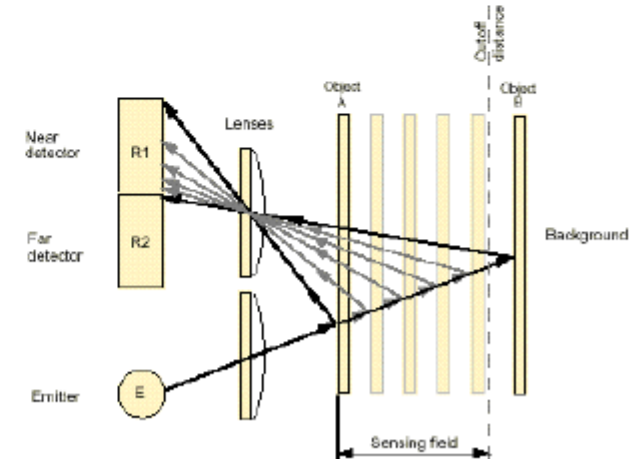
Object is sensed if amount of light at R1 is greater than the amount of light at R2

Beam Pattern and Reflectance

Typical Beam Pattern

INCHES (vertical axis): 60, 40, 20, 0, 20, 40, 60
OPPOSED DISTANCE--FEET (horizontal axis): 0, 30, 60, 90, 120, 150

Effective Beam

- Range
- Radiation Pattern
- Effective Beam
- Emitter
- Receiver
- Field of View
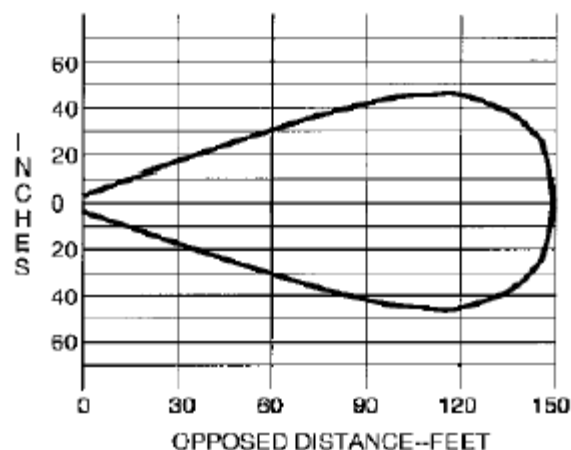
RELATIVE REFLECTIVITY TABLE

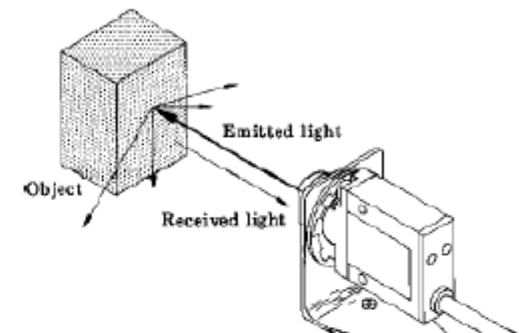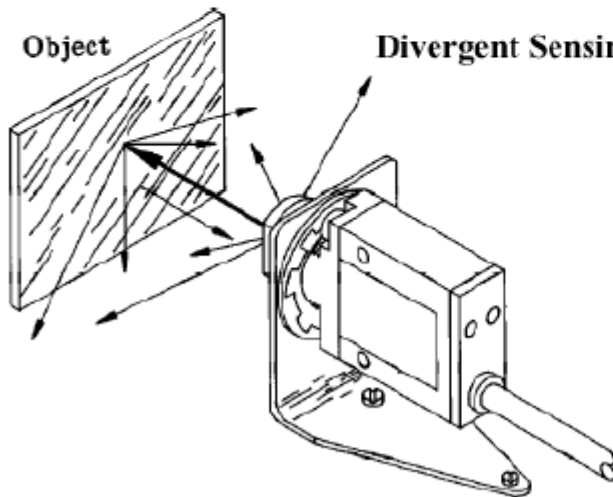| Material	Reflectivity (%)	Excess Gain Required
Kodak white test card	90%	1
White paper	80%	1.1
Masking tape	75%	1.2
Beer foam	70%	1.3
Clear Plastic*	40%	2.3
Rough wood pallet (clean)	20%	4.5
Black neoprene	4%	22.5
Natural aluminum, unfinished*	140%	0.6
Stainless steel, microfinish	400%	0.2
Black anodized aluminum*	50%	1.8

*NOTE: For materials with shiny or glossy surfaces, the reflectivity figure represents the maximum light return, with the sensor beam *exactly perpendicular* to the material surface
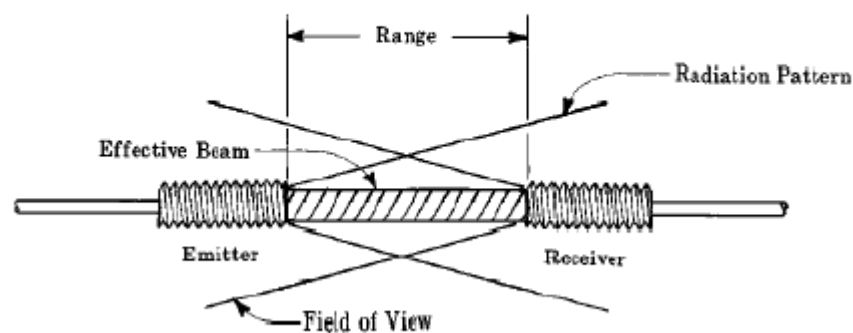
Specular Reflection
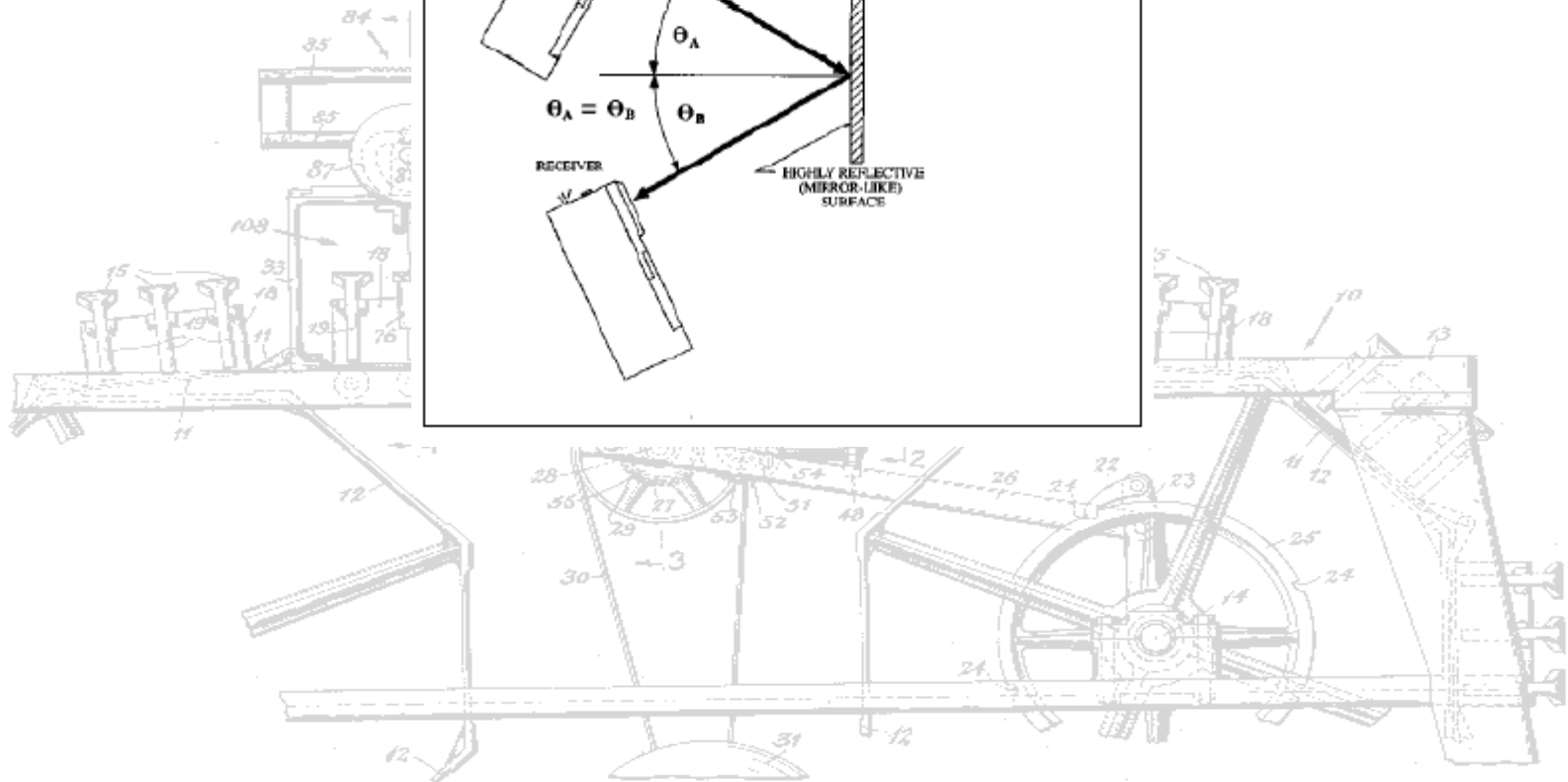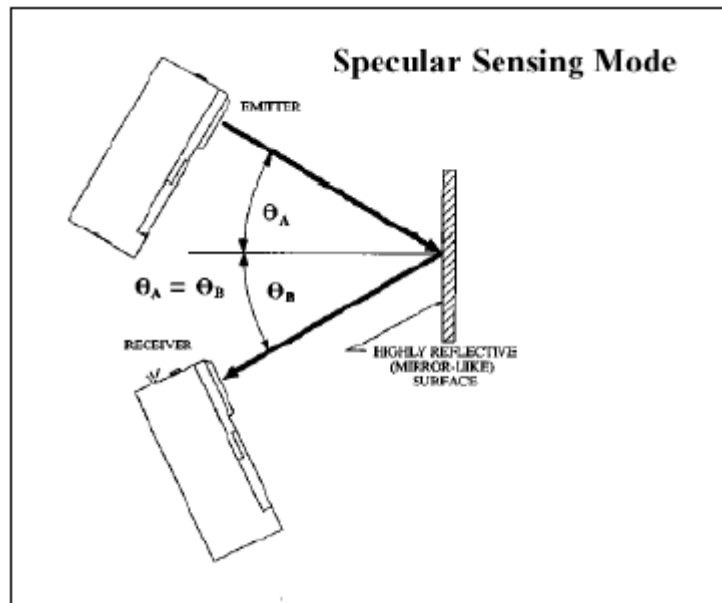
Modulation

- "Chop" LED on and off at many kHz rate

- Bandpass filter after photodiode at the same frequency as chopping

- Threshold circuit after BPF generates on/off output
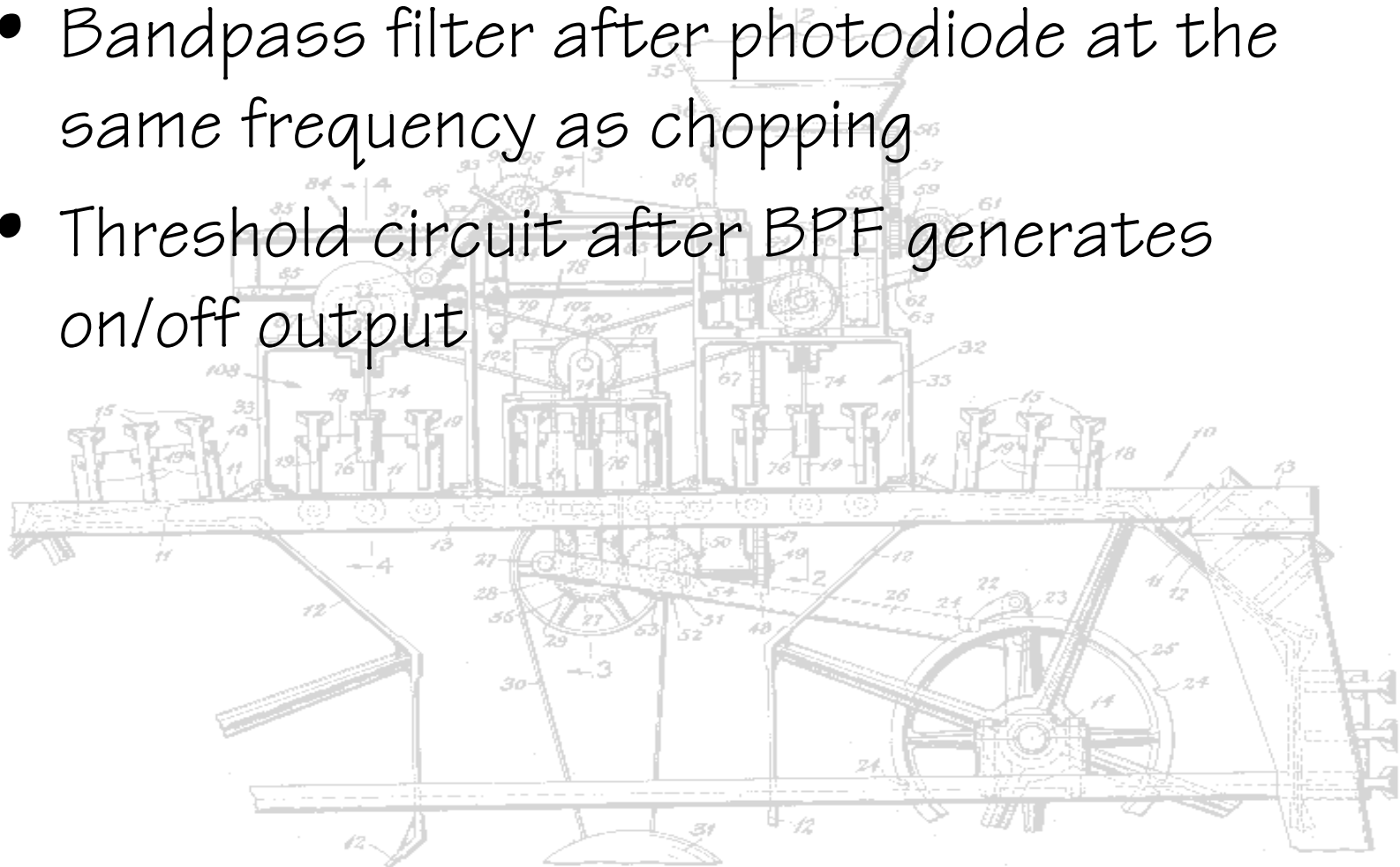
Magnetic Position Sensors

- Reed switches (sense permanent magnet)

- Inductive proximity sensors (eddy current)

- Hall Sensors (sense permanent magnet)

Inductive Proximity Sensor

Sensing field

Metal target
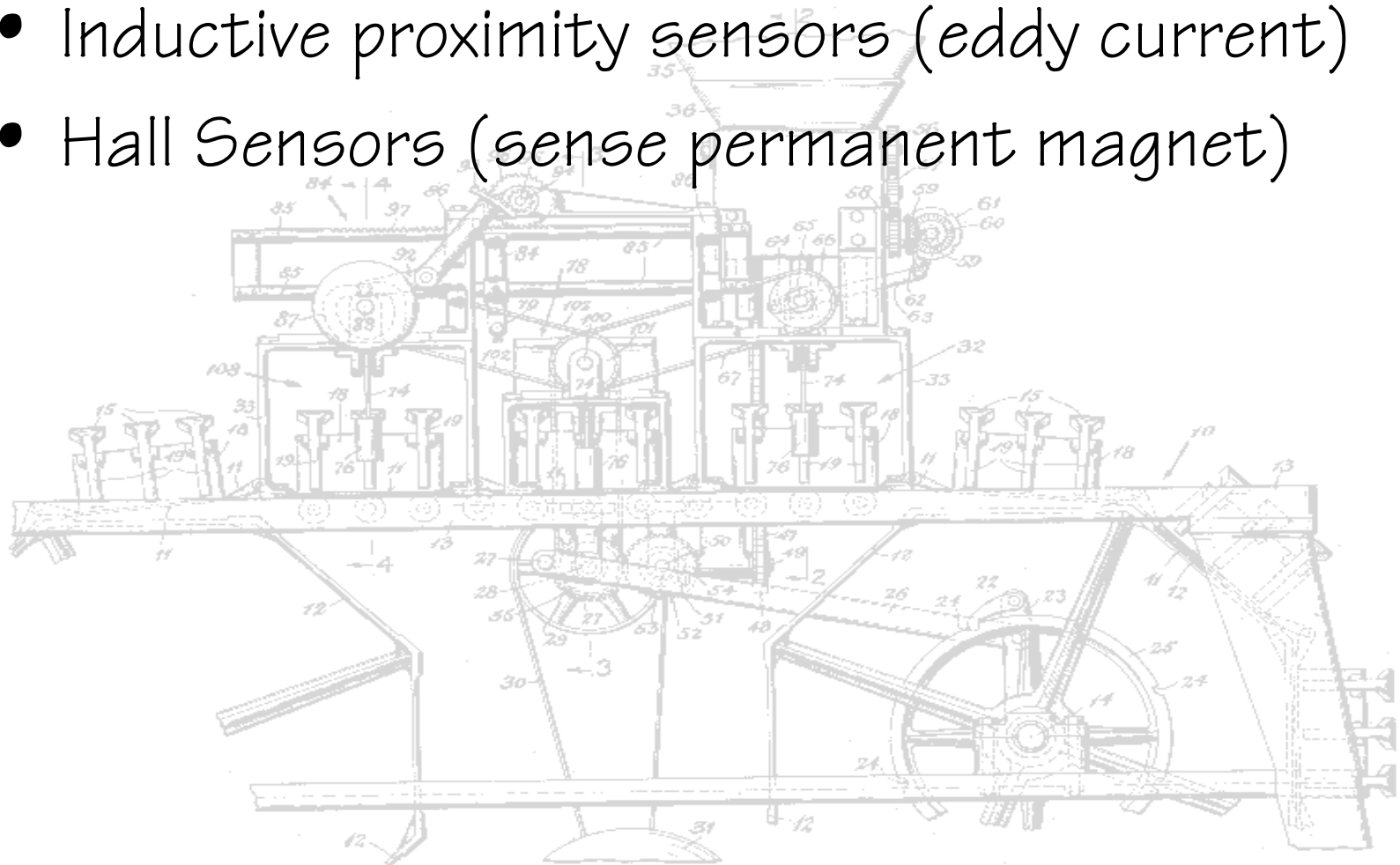
Inductive Proximity Sensor
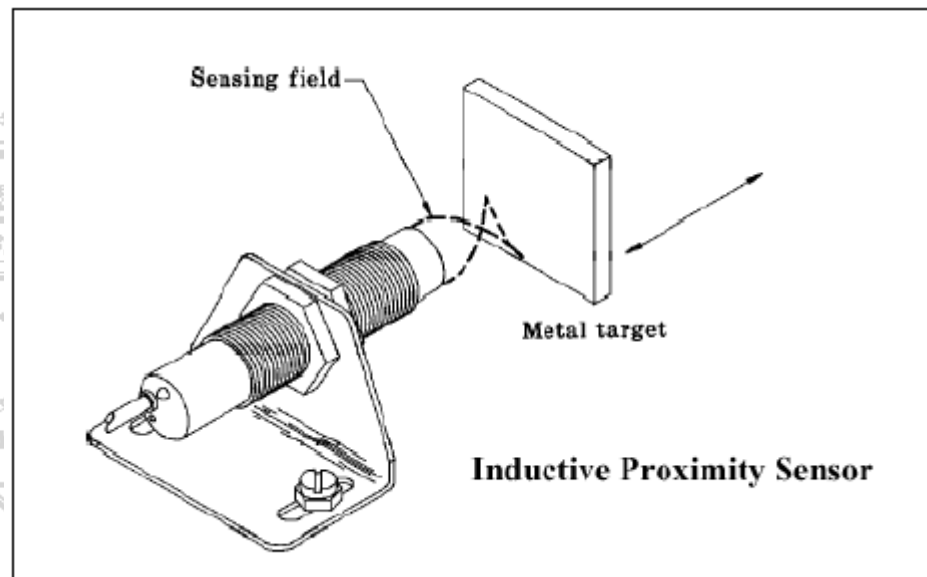
Inductive Proximity Sensors
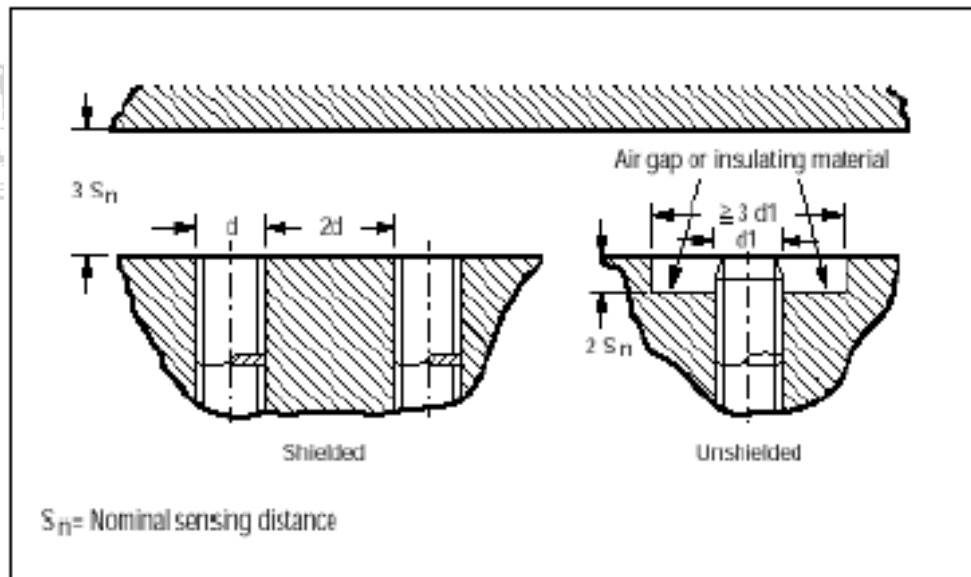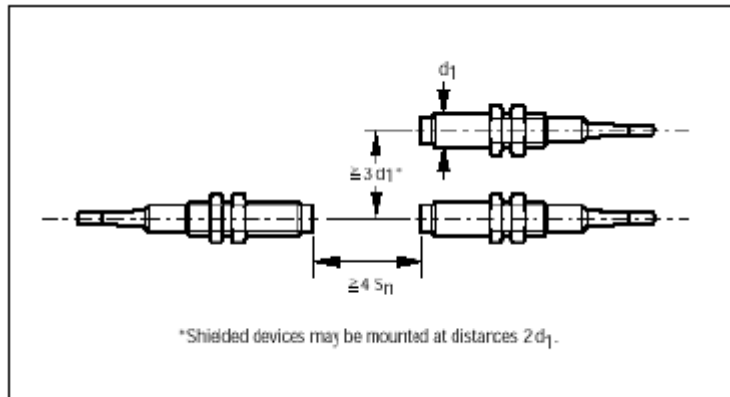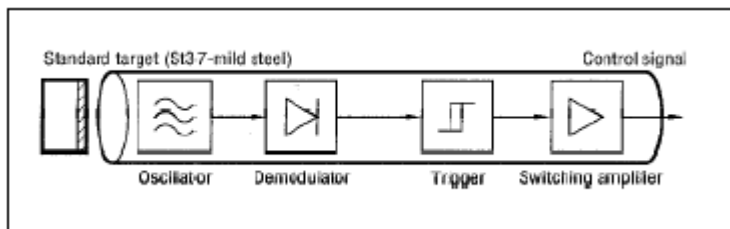
Hall Sensors

- Hall *effect:*
  - constant voltage forces a constant current in semiconductor sheet
  - magnetic field flux lines perpendicular to current cause proportional voltage across sheet.
  - discovered by E.F.Hall in 1879
- *Linear sensor needs voltage regulator and amplifier*
- *Switch also needs threshold circuit, with hysteresis*

Hall Switch

- Magnet motion
  - head-on
  - bypass or slide-by
- Total effective air gap (TEAG)
- Sensitivity, Hysteresis, & Temperature
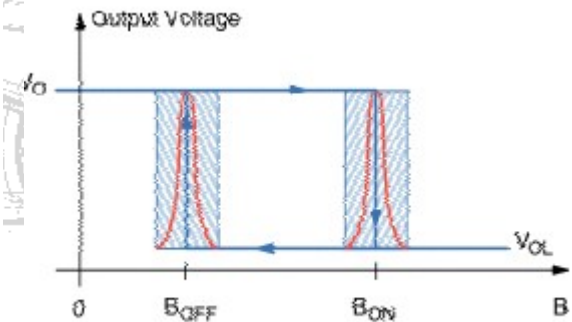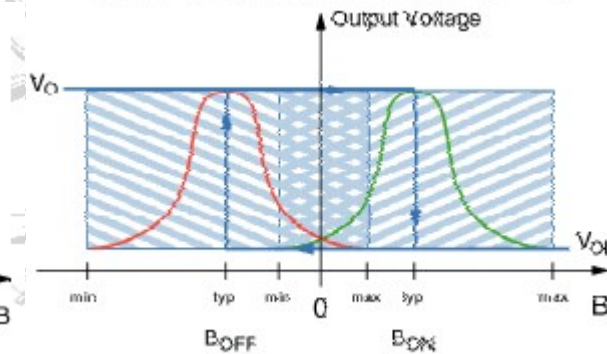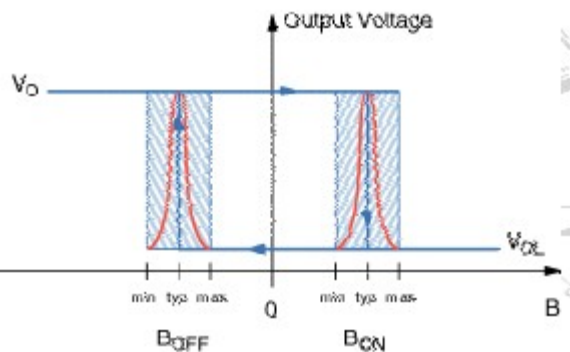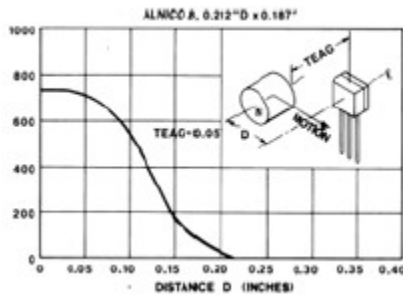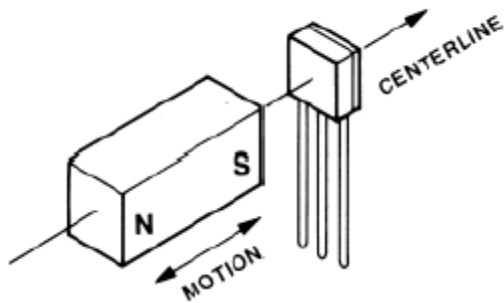
Other Discrete Position Sensors

- capacitive

- ultrasonic

- variable reluctance (coil around magnet, senses moving ferrous material)
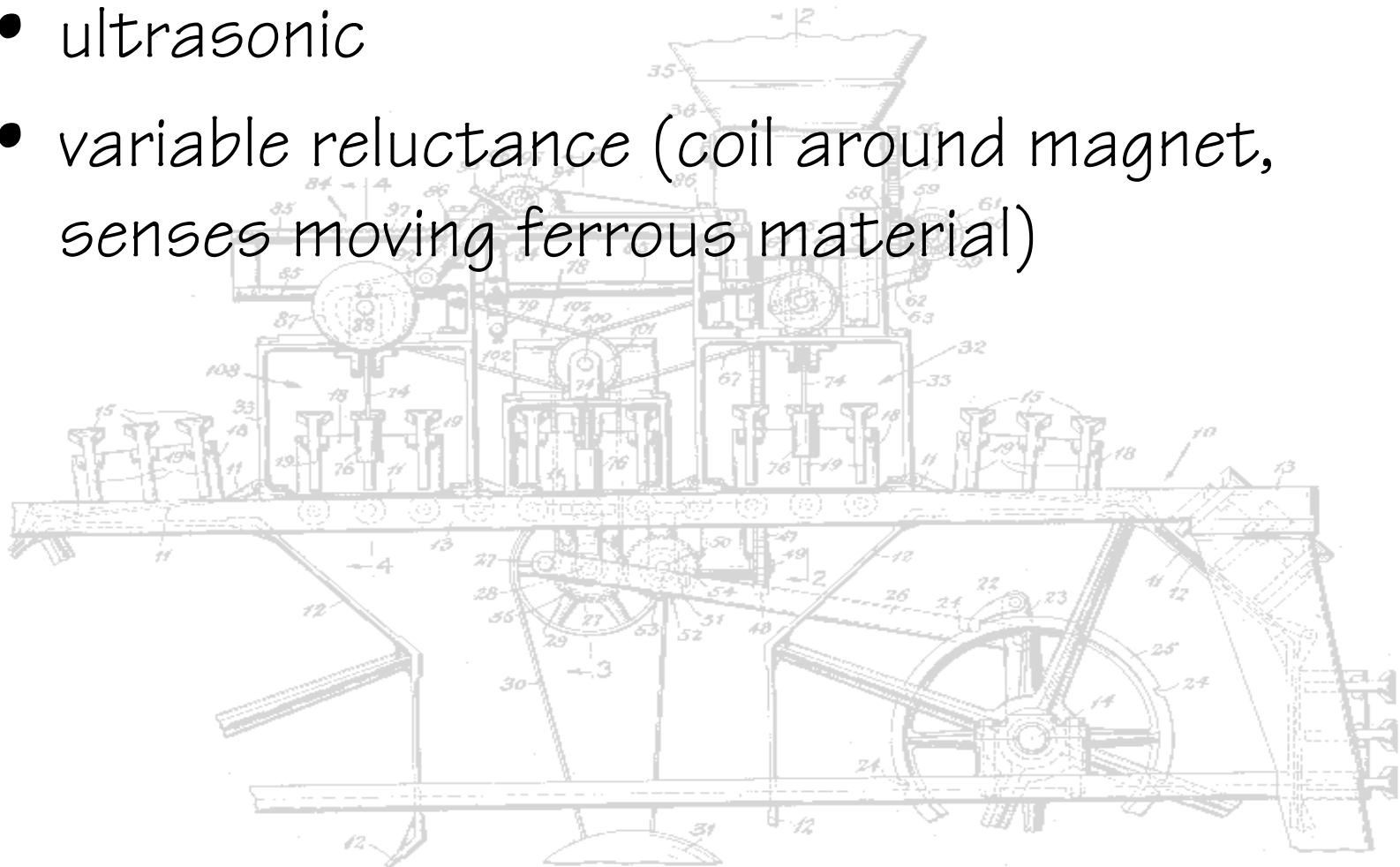
Incremental Encoders
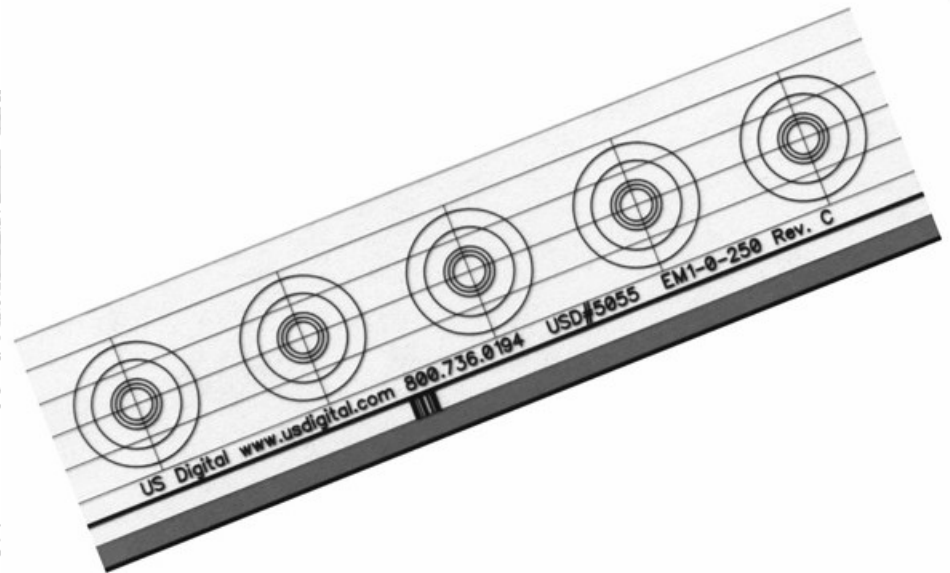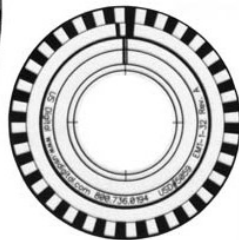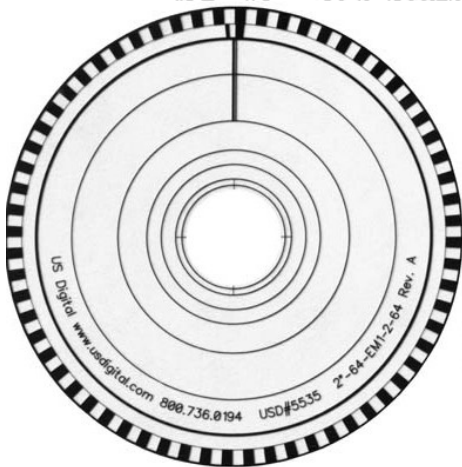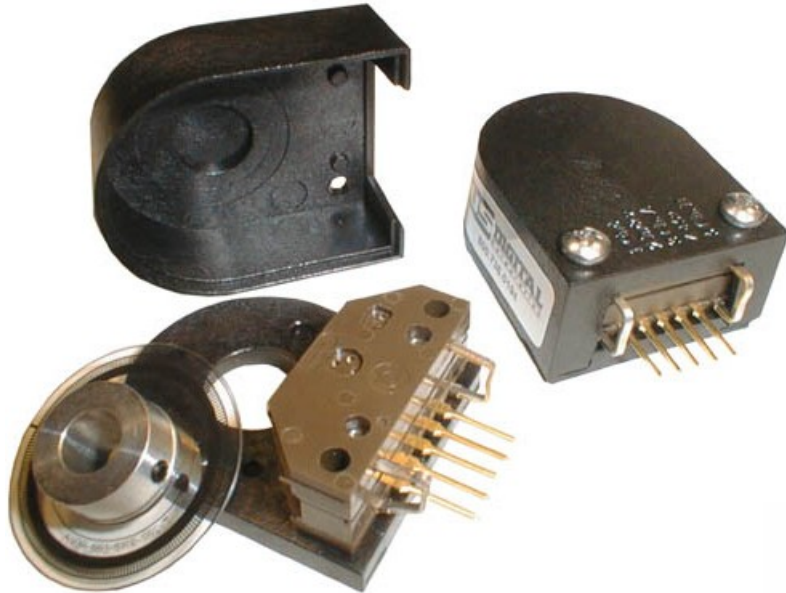
Incremental Encoders

- Encoders typically run on +5V, not +24V

- Outputs are typ. not 24V compatible either

Block Diagram:

J1 5-pin Screw Terminal Connector

Input C 5
+5VDC 4
Input B 3
Input A 2
Ground 1

PS-9V Interface (optional)

DC to DC Converter

2.7 kOhms Pull-up Resistors

7.5 kOhms Pull-up Resistors

Output Driver

12 Output driver VCC
11 +5VDC output
10 +5VDC output — jumper A
9 6.5 to 25 VDC input — jumper B
8 6.5 to 25 VDC input
7 C- output
6 C+ output
5 B- output
4 B+ output
3 A- output
2 A+ output
1 Ground

Input C 5
+5VDC 4
Input B 3
Input A 2
Ground 1

J2 5-pin Finger-latching Connector

Note: Jumper A or Jumper B must be connected for output operation. Connect jumper A for 5 volt output or connect jumper B for high voltage output.

Absolute Encoders

- doubling resolution requires adding another photodiode/LED pair

- cost is much higher than incremental

- does not require seeking to establish reference location
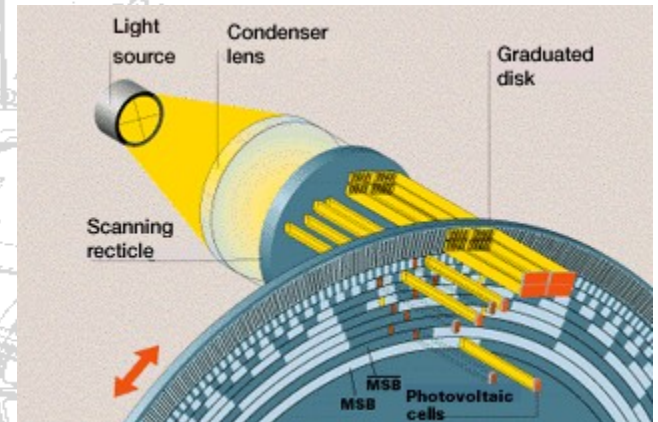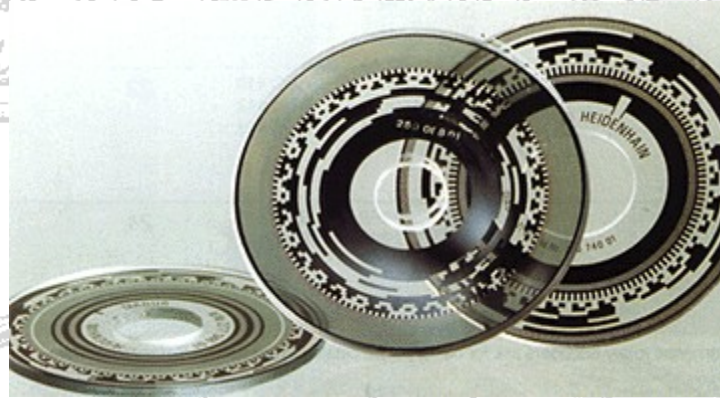
HYBRID INCR/ABSOLUTE ENCODERS

- add more information to index channel to reduce amount of seeking required to find reference position.

- interface requires lots of wires (parallel) or a special comm. protocol

Potentiometer

- A potentiometer (or pot) is a variable resistor wired to obtain a variable DC voltage proportional to position

Gold Plated Terminals

Stainless Steel Shaft

Precious Metal Slip Ring Contacts

Brass Bushing

Element
Conductive Plastic Shown

Patented Precious Metal Wiper
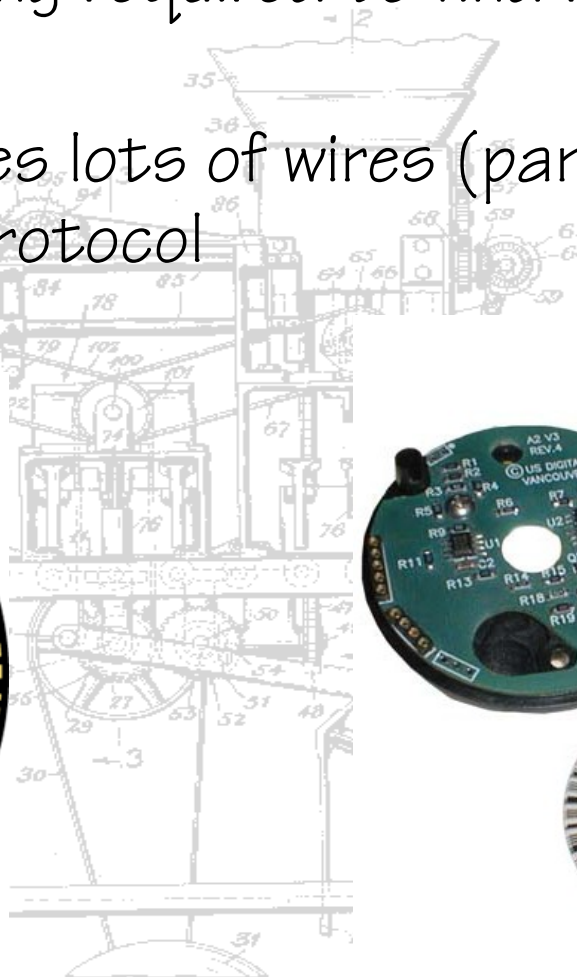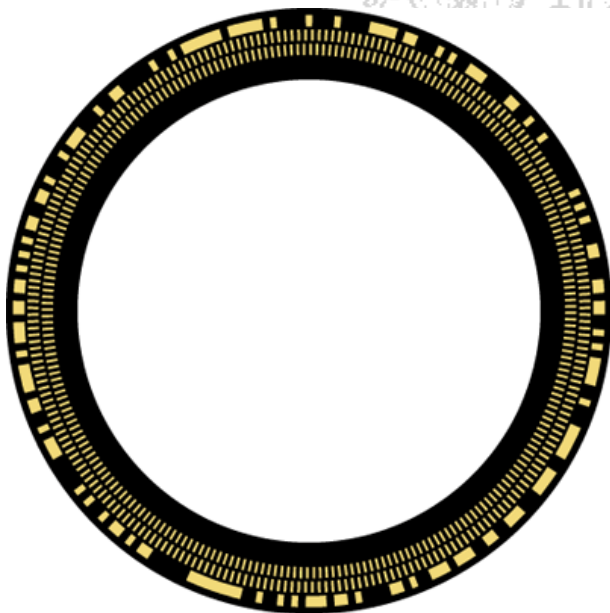
Element

Gold Plated Terminals

Anti-backlash wave washer

Guide Rails

Stainless Steel Shaft

Patented Precious Metal Wiper

Shaft Modifications
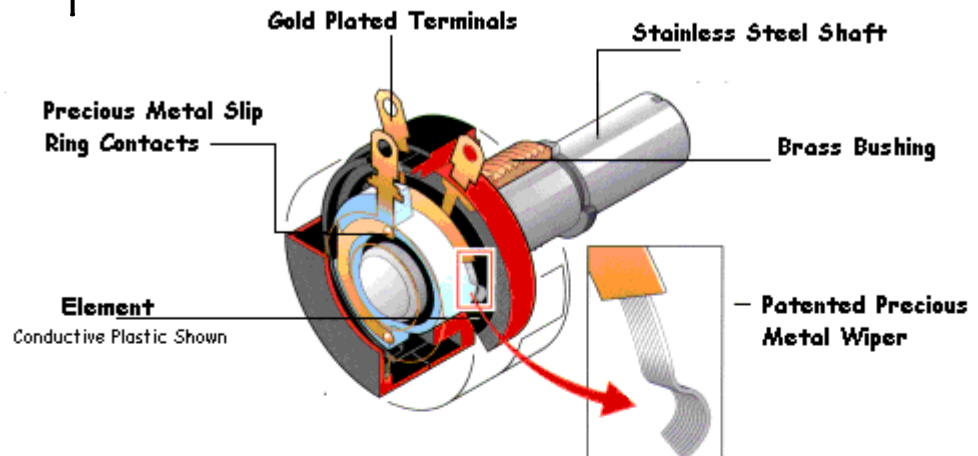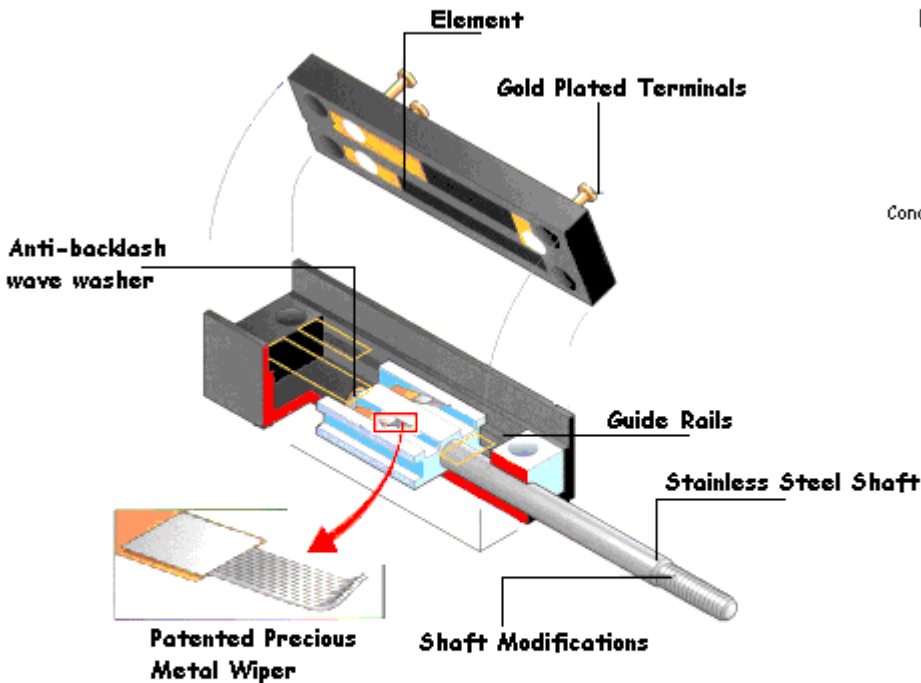
Mounting Types
Bushing mount : Most commonly used. Mounts easily in the panel hole and secures with a mounting nut.
Servo mount : Recommended when the shaft is to be attached to a gear or other mechanism. Allows the operator to index to zero adjustment by turning the potentiometer.

Servo cleat
3 required

Mounting Panel

Magnetostrictive Pos. Sensor

Interrogation pulse forms magnetic field along entire waveguide for 1 to 3 microseconds

Sensor element head

Sensor element protective tube

Waveguide

Magnetic field from position magnet
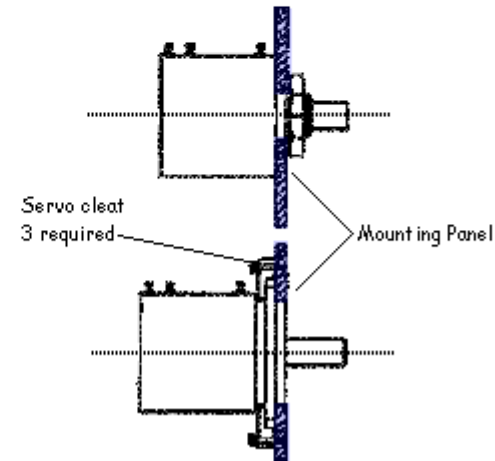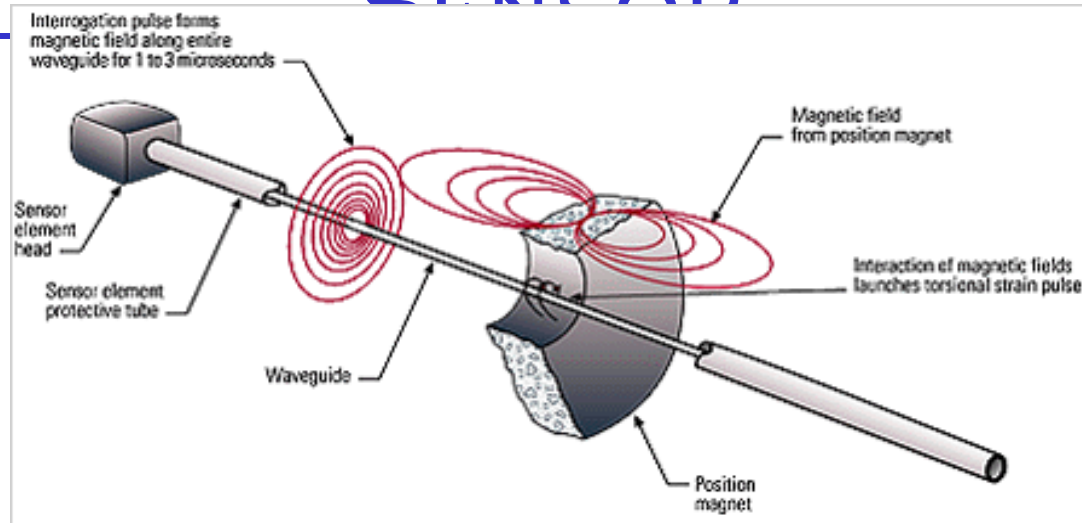
Interaction of magnetic fields launches torsional strain pulse

Position magnet

- Pulse sent down magnetostrictive material
- Pulse reflects off position magnet's field
- Position is proportional to t_{rcvd} - t_{sent}
- Pulse propagates at ~2800 m/s
- Resolution is ~.001" with t_{update} ~1msec/in.

Magnetostrictive Sensor

Movable Position Magnet

Magnetic field encompasses entire waveguide-generated by interrogation pulse

Interrogation: Return Wire Waveguide

Pulse Output

Strain Pulse Detector

Magnetic Field from Position Magnet

Interaction of magnetic fields causes waveguide to generate a strain pulse