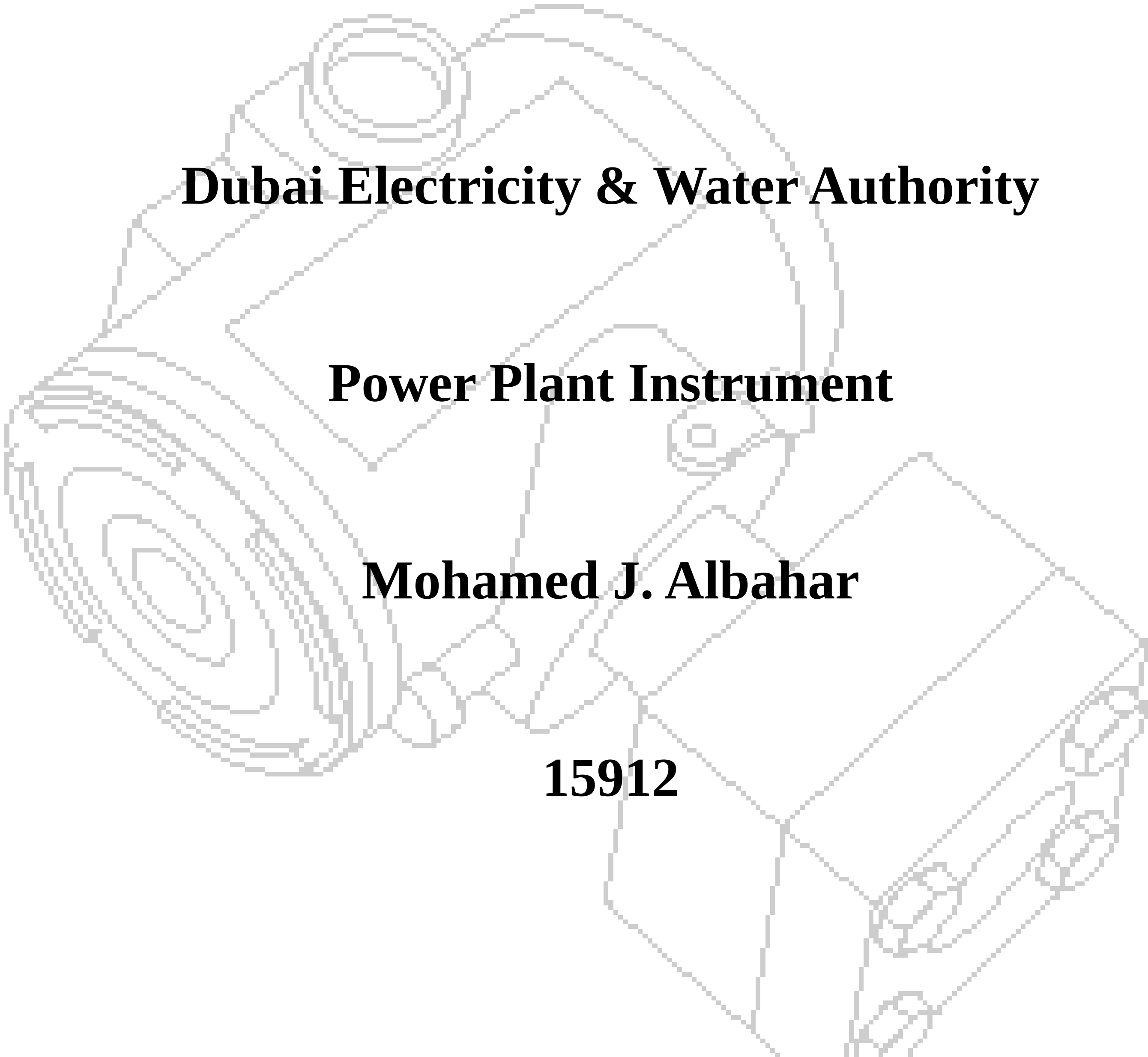


Dubai Electricity & Water Authority

Power Plant Instrument

Mohamed J. Albahar

15912

Table of Content

Hazardous area reference, classifications & enclosure data
North America area classification

Class I (Explosive Gases)

- **Division 1** (Gases normally present in explosive amounts)
- **Division 2** (Gases not normally present in explosive amounts)

Gas types by group.

  - **Group A Acetylene**
  - **Group B Hydrogen**
  - **Group C Ethylene and related products**
  - **Group D Propane and alcohol products**

Class II (Explosive Dusts)

- **Division 1** (Dust normally present in explosive amounts)
- **Division 2** (Dust not normally present in explosive amounts)

  Dust types by group.

  - **Group E Metal dust**
  - **Group F Coal Dust**
  - **Group G Grain and non-metallic dust**

Class III (Explosive fibers)

- **Division 1** areas (Fibers normally present in explosive amounts)
- **Division 2** areas (Fibers not normally present in explosive amounts)

Hazardous area reference, classifications & enclosure data
European area classification

Explosive Gases

1st Criteria:

- **Group I -** Products intend for underground mines that are subject to firedamp (Methane Gas)
- **Group II -** Products intend for all other explosive gas atmospheres except for Group I areas

2nd Criteria: Determine type of gas subdivision

- **A -** Hydrocarbons, Oxygen, Halogen, Sulfur, and Nitrogen (less explosive concentrations and types)
- **B** - Hydrocarbons, Oxygen, Halogen, Sulfur, and Nitrogen (more explosive concentrations and types)
- **C** - Acetylene, hydrogen, carbon disulfide

3rd Criteria: Establish Zone.

Zone 0 - Explosive gas is continuously present

Accepted protection standard: **Ex ia intrinsically safe**

Zone 1 - Explosive gas is often present

Accepted protection standard: **Ex ib intrinsically safe**

Ex d flame-proof

Ex e increased safety

Ex o oil immersed

Ex p purged and pressurized

Ex q powder filled

Ex m encapsulated

Zone 2 - Explosive gas may be accidentally present

Accepted protection standard :

Ex n non-sparking and/or non-ignition capable

.

- **4th Criteria:** Temperature Rating.

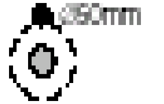
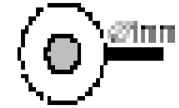
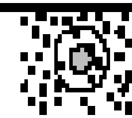
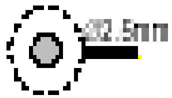
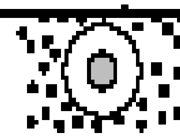
T-Code - Maximum operating temperature of device.

Explosive Dusts

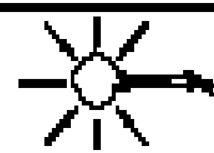
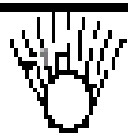
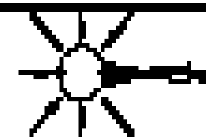
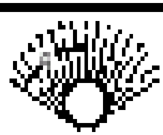
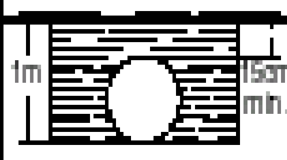
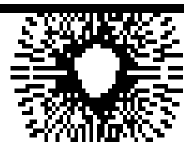
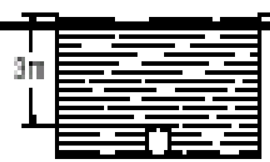
Zone 21 - Explosive metallic dusts are present

Zone 22 - Explosive non-metallic dusts are present

1st Figure: Protection against solid bodies

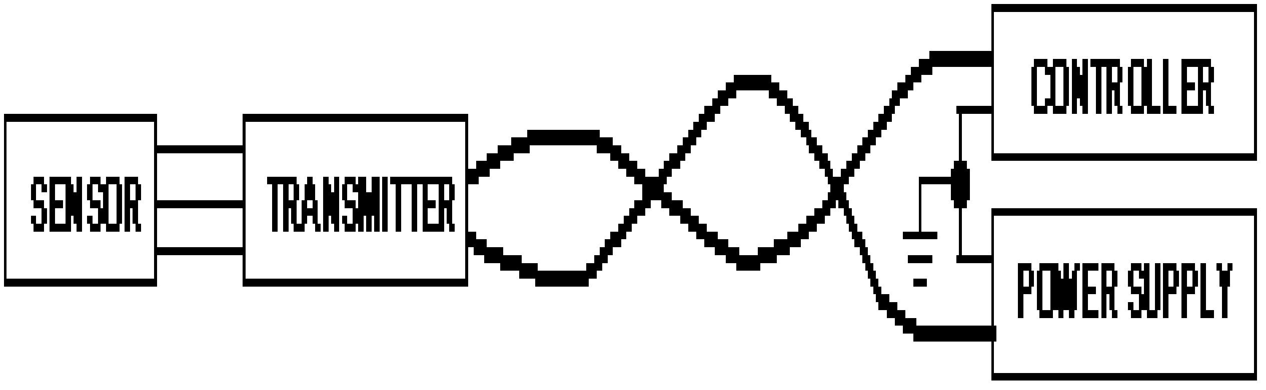
IP	Tests	Description	IP	Tests	Description
1		Protected against solid bodies larger than 50mm. (eg. : accidental contact with the hand)	4		Protection against solid bodies larger than 1mm (fine tools, small wires)
2		Protected against solid bodies larger than 12.5mm (eg. : finger of the hand)	5		Protected against dust (no harmful deposit)
3		Protected against solid bodies larger than 2.5mm (tools, wires)	6		Completely protected against dust

2nd Figure: Protection against liquids

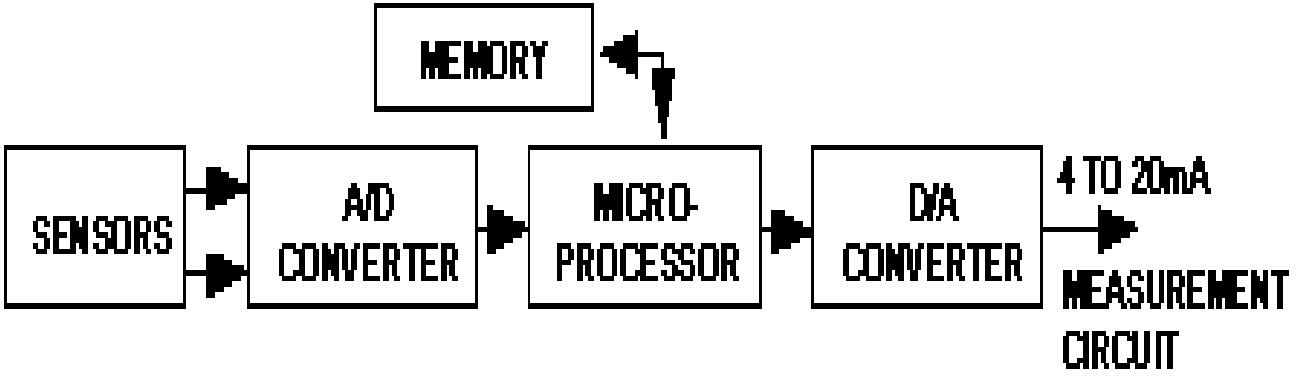
IP	Tests	Description	IP	Tests	Description
1		Protected against vertically-falling drops of water. (condensation)	5		Protected against jets of water from all directions
2		Protected against drops of water falling up to 15° from vertical.	6		Completely protected against jets of water of similar force to heavy seas
3		Protected against drops of water falling up to 60° from vertical.	7		Protected against the effects of immersion
4		Protected against projections of water from all directions	8		Protected against prolonged immersion under specified conditions

Transmitters

- Conventional transmitter (Analogue)
- consists of
  – a power supply
  – a current-manipulating transmitter
  – a receiving controller



- Smart transmitter
  - Microprocessor
  - ADC & DAC
  - It condition the signal remotely before transmission



HART Protocol & FSK modulation

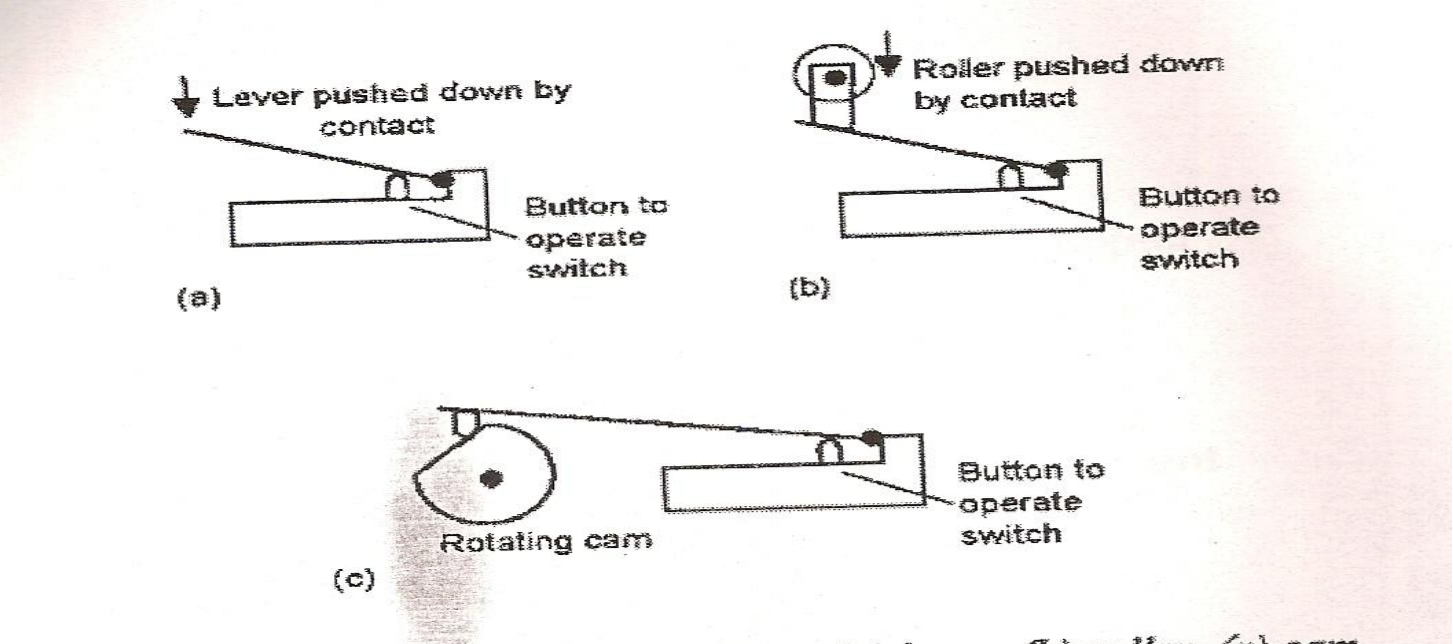
- Highway Addressable Remote Transducer (HART) protocol
- frequency-shift keying (FSK)
- The loop current is transmitted at 1200 bits/second as one of two phase-continuous frequencies
  - 1.2 kHz- Level (1)
  - 2.2 kHz- Level(0)

Mechanical Switches

- ON – OFF
- Level 1 corresponds to a 24 V d.c
- Level 0 corresponds to a 0   V d.c

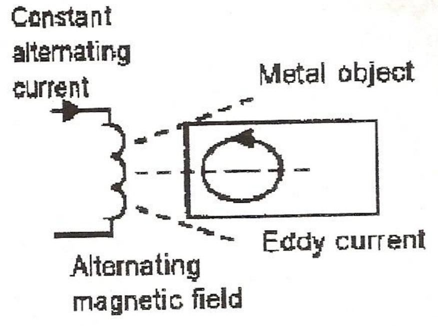
Limit switches

- To detect the presence or passage of a moving part
- It can be activated by a cam, roller or lever.

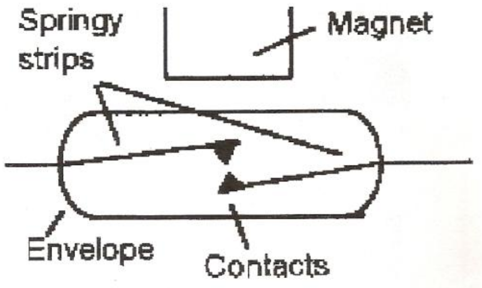


Limit switches actuated by: (a) lever, (b) roller, (c) cam

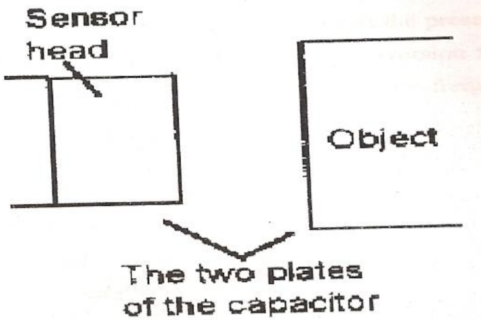
Proximity switch



Eddy current proximity switch

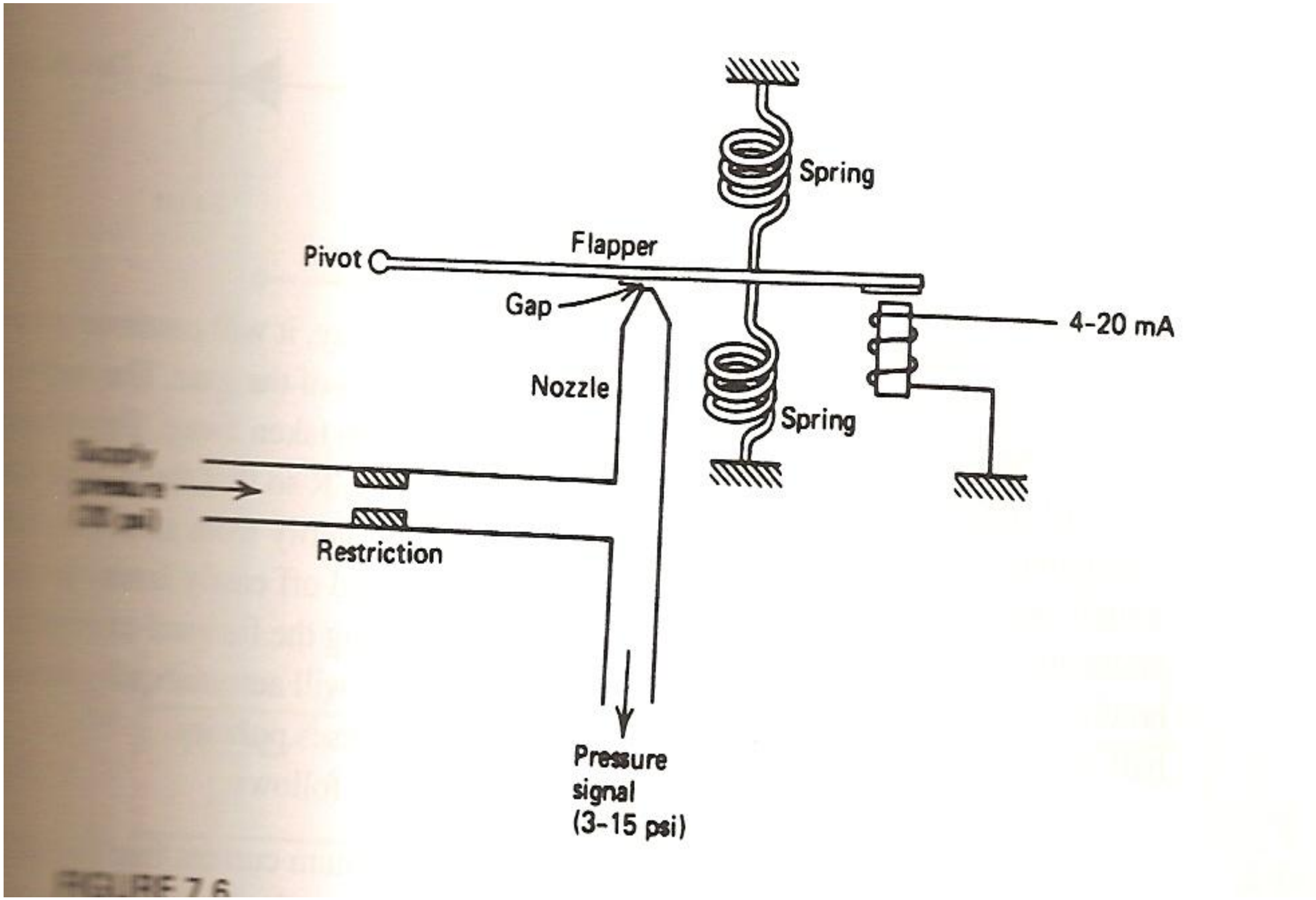


Reed

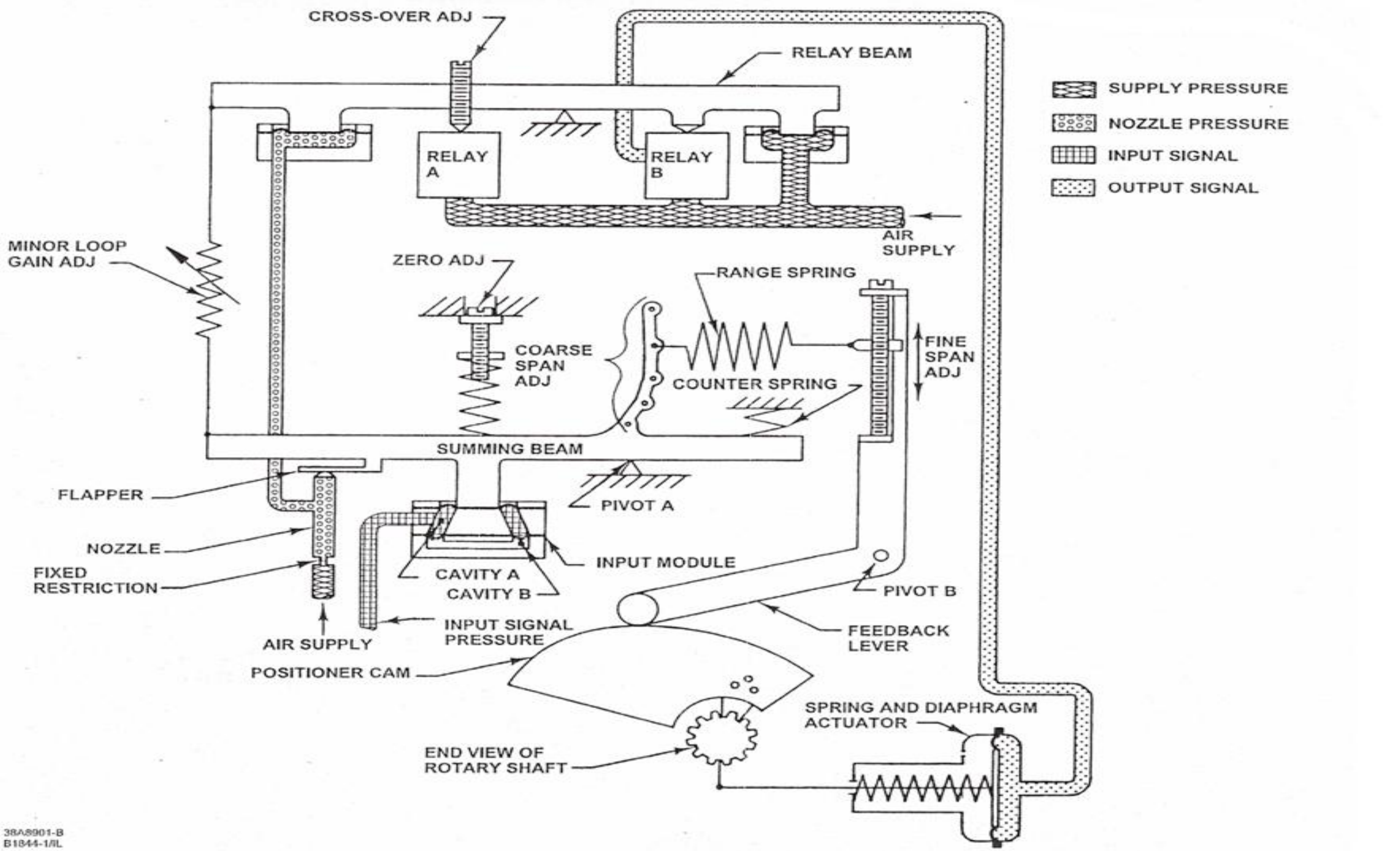


Capacitive proximity

I/P Converter

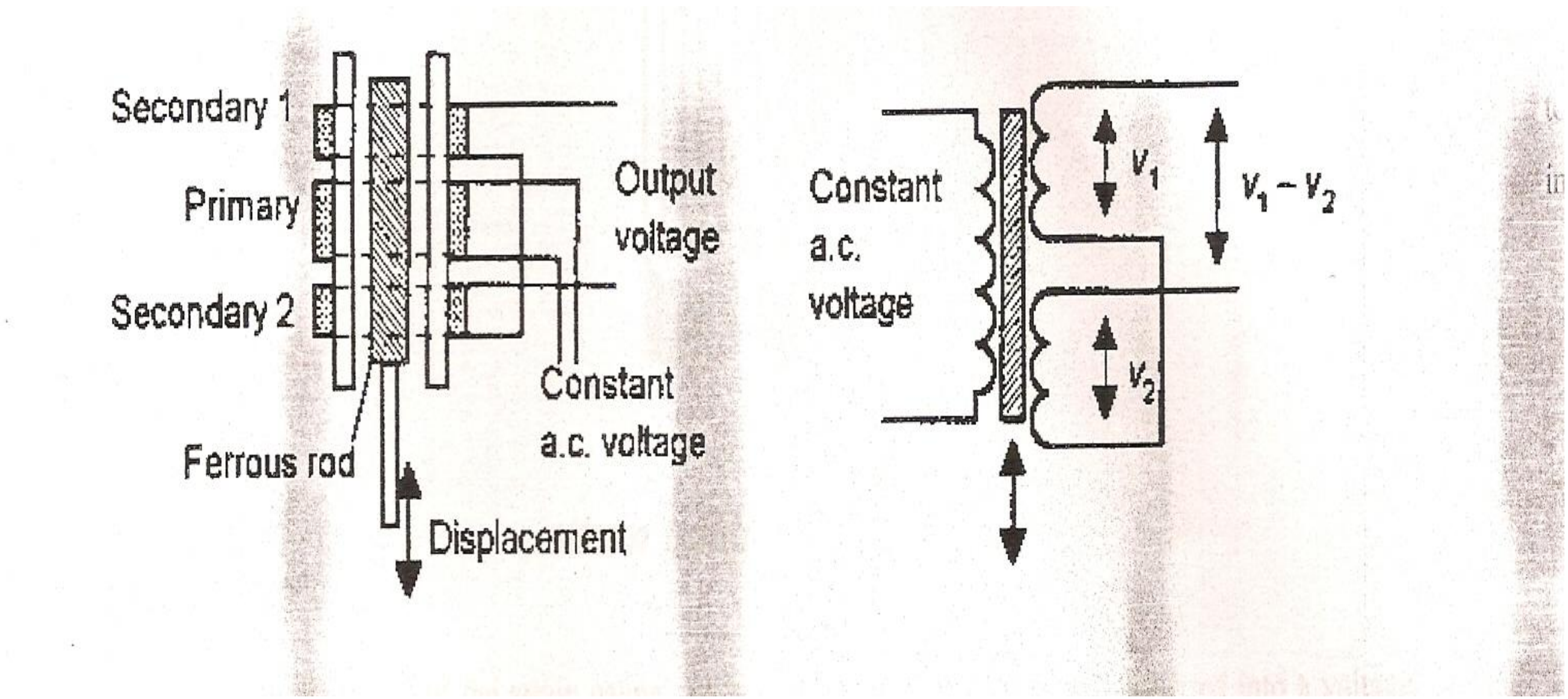


Positioner


CROSS-OVER ADJ
RELAY BEAM
SUPPLY PRESSURE
NOZZLE PRESSURE
INPUT SIGNAL
OUTPUT SIGNAL
RELAY A
RELAY B
AIR SUPPLY
MINOR LOOP GAIN ADJ
ZERO ADJ
RANGE SPRING
COARSE SPAN ADJ
FINE SPAN ADJ
COUNTER SPRING
SUMMING BEAM
FLAPPER
PIVOT A
NOZZLE
INPUT MODULE
FIXED RESTRICTION
CAVITY A
CAVITY B
PIVOT B
INPUT SIGNAL PRESSURE
AIR SUPPLY
FEEDBACK LEVER
POSITIONER CAM
SPRING AND DIAPHRAGM ACTUATOR
END VIEW OF ROTARY SHAFT
38A8901-B
B1844-1/IL

LVDT

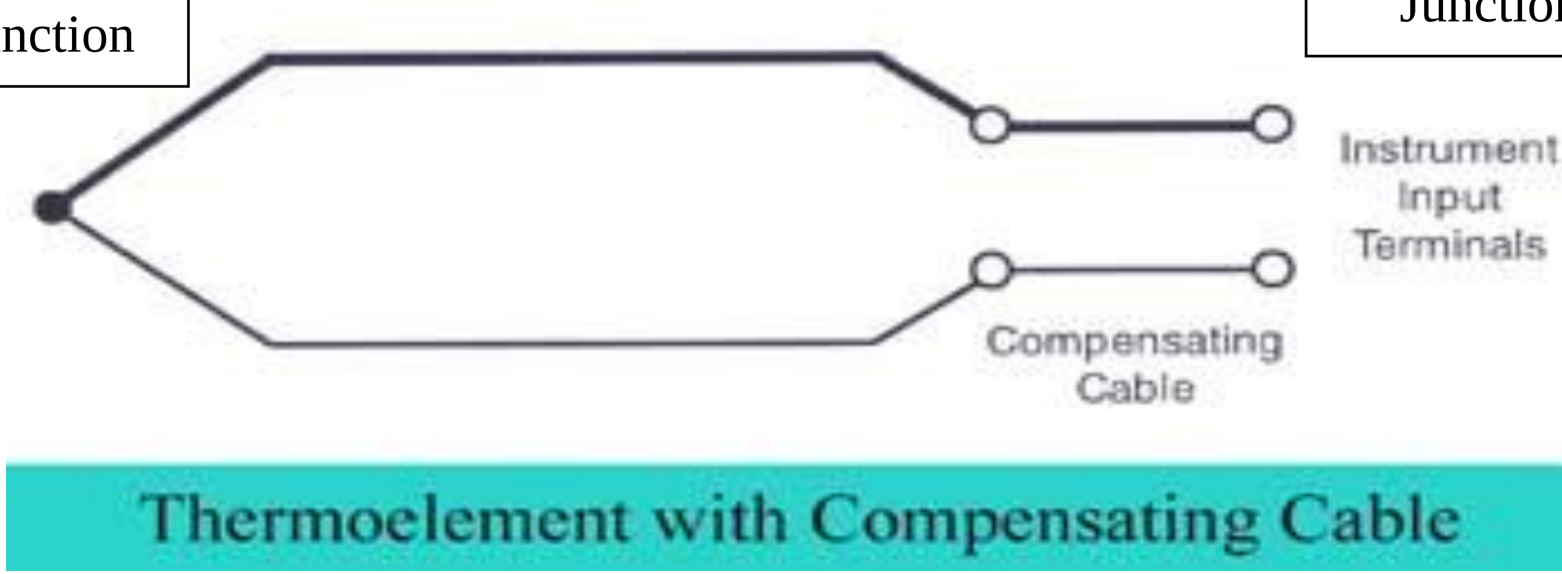
- Linear Variable Differential Transformer
- Movable core with three coils



Temperature sensors

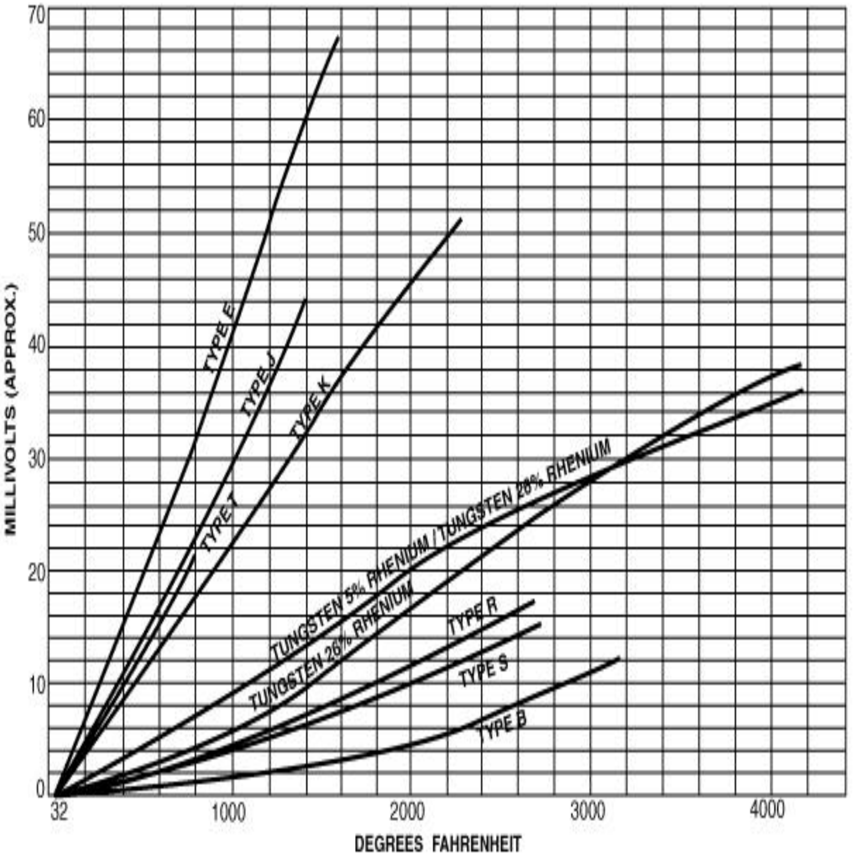
- Thermocouple
- RTD
- Thermostat
- thermistors

Thermocouples



Type of thermocouple depends on the material used that determine the range

Type	Temperature Range
T	- 200 to 350
J	0 to 750
E	-200 to 900
K	-200 to 1250
R, S	400 to 1400
B	800 to 1800
N	0 to 1250



RTD

- PT 100 (platinum)
- at 0 C = 100 Ohms

$$R_x = \frac{R_2 R_3}{R_1}$$

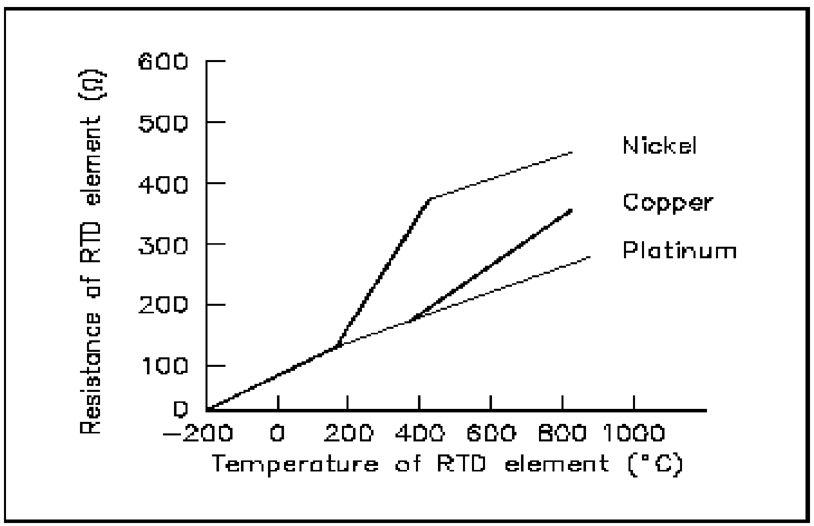


Figure 1 Electrical Resistance-Temperature Curves

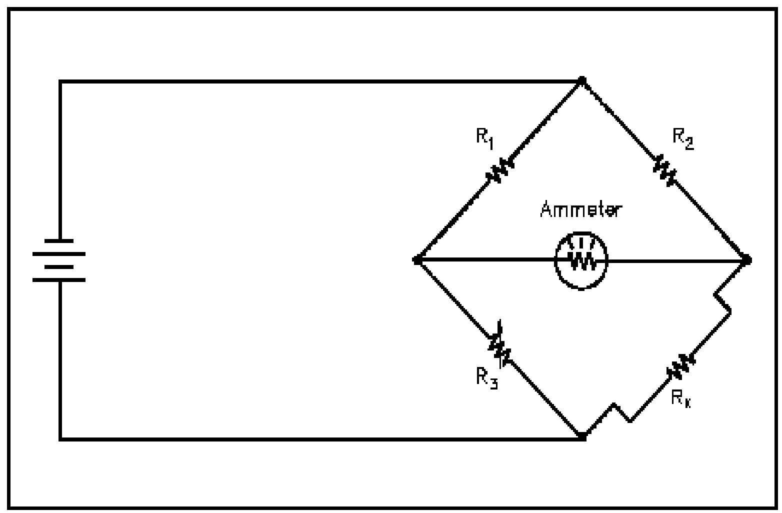
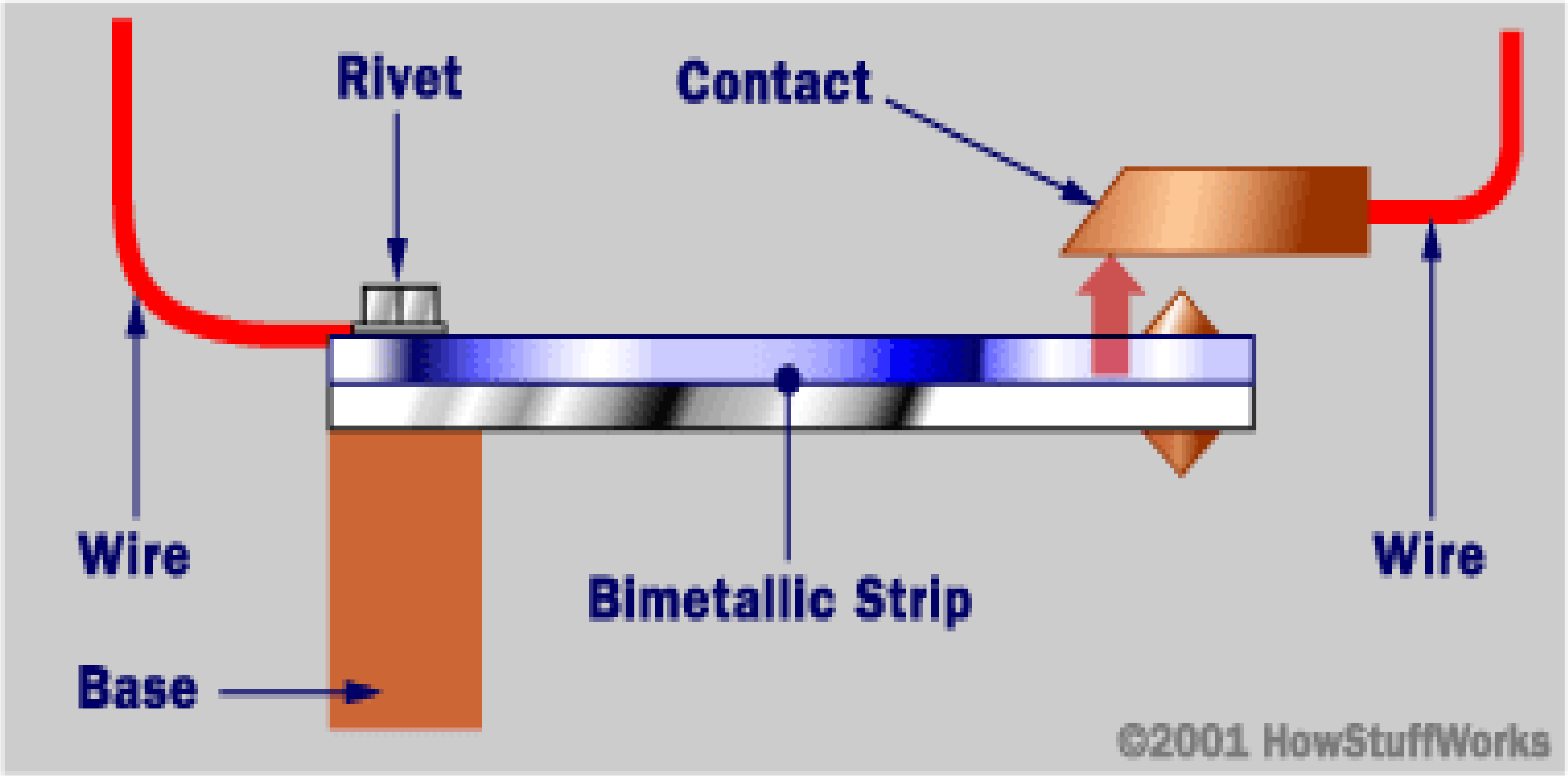


Figure 8 Bridge Circuit

Thermostat



Rivet
Contact
Wire
Wire
Bimetallic Strip
Base
©2001 HowStuffWorks

Pressure Sensors

- Capacitive
- Inductive
- Strain gauge
- Resistance
- Bourdon tube
- Bellows

Capacitive-Type Transducers

consist of
two flexible conductive plates and a dielectric fluid.

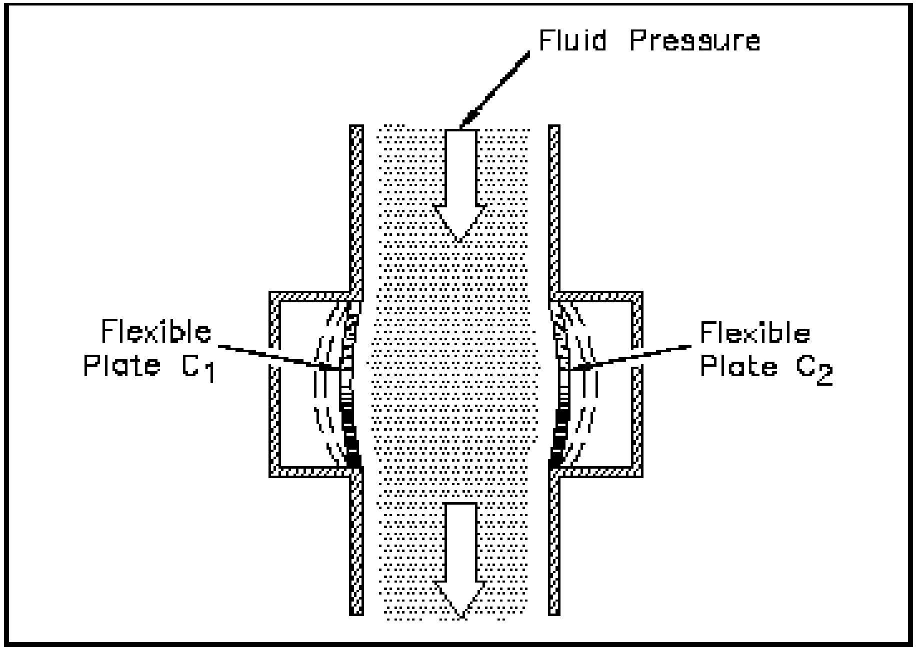


Figure 9 Capacitive Pressure Transducer

Inductance-Type Transducers

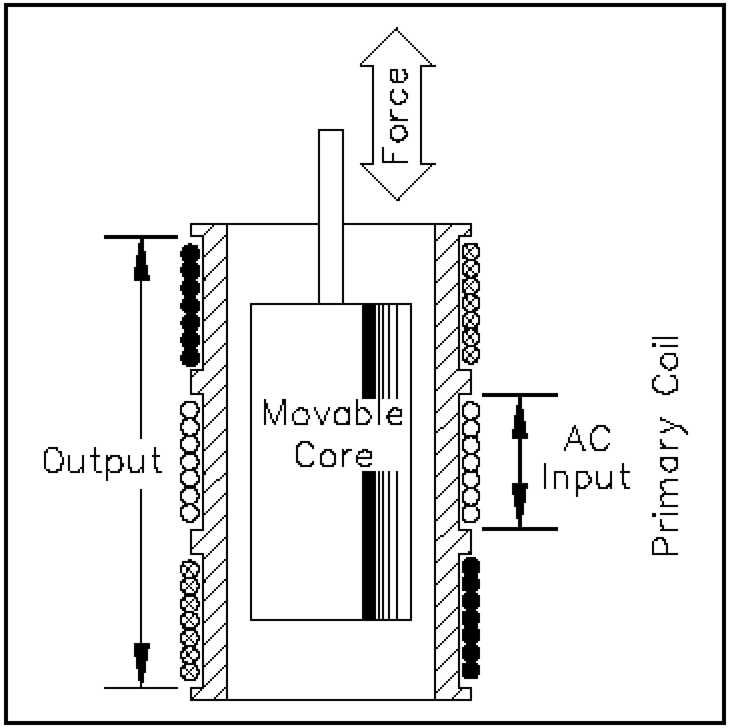
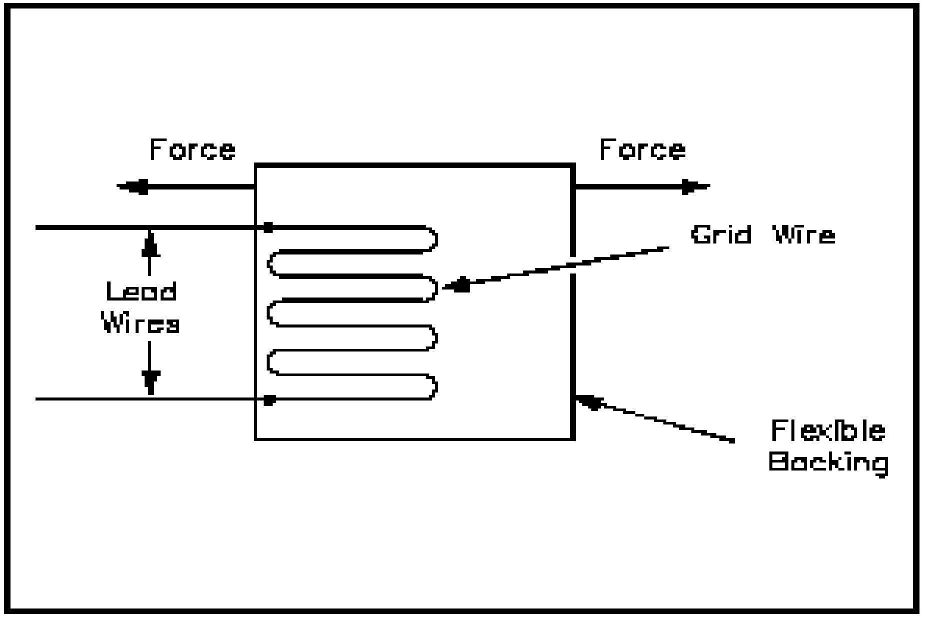


Figure 8 Differential Transformer

Resistance-Type Transducers



Strain Gauge

$$R = K\frac{L}{A}$$

R = resistance of the wire grid in ohms

K = resistivity constant for the particular type of wire grid

L = length of wire grid

A = cross sectional area of wire grid

Strain gauge pressure transducer.

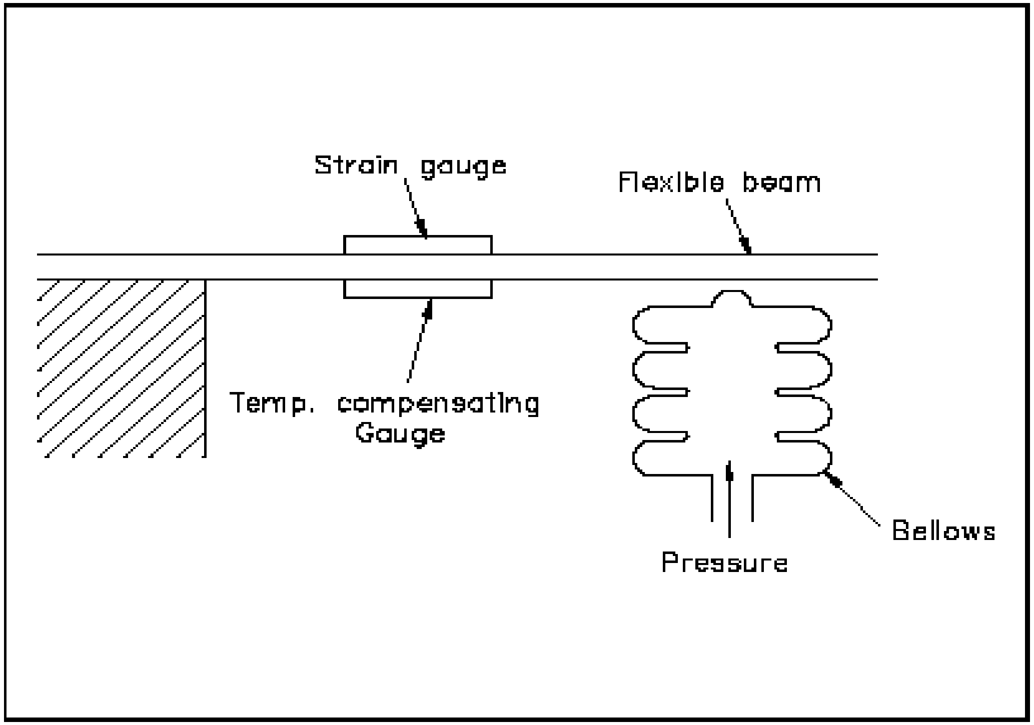


Figure 4 Strain Gauge Pressure Transducer

Used with a diaphragm to detect the deflection of the plastic

Connected to a bridge circuit

Bourdon Tube-Type Detectors

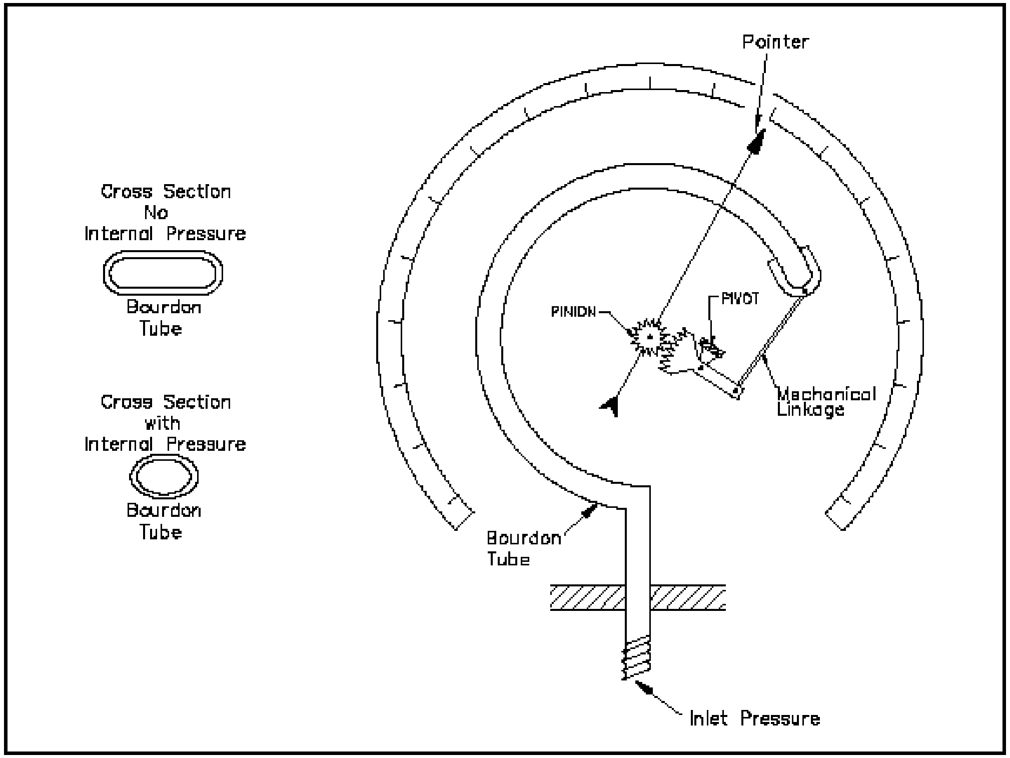


Figure 2 Bourdon Tube

Bellows-Type Detectors

measuring pressures from 0.5 to 75 psig

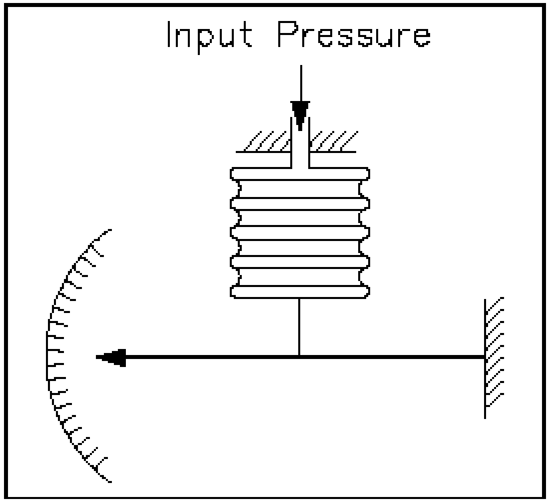
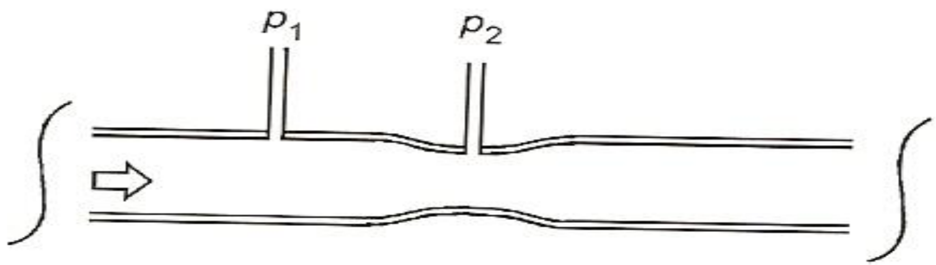


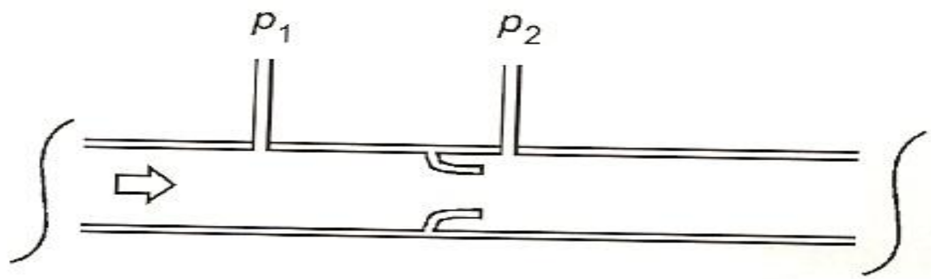
Figure 1 Basic Metallic Bellows

Flow sensors

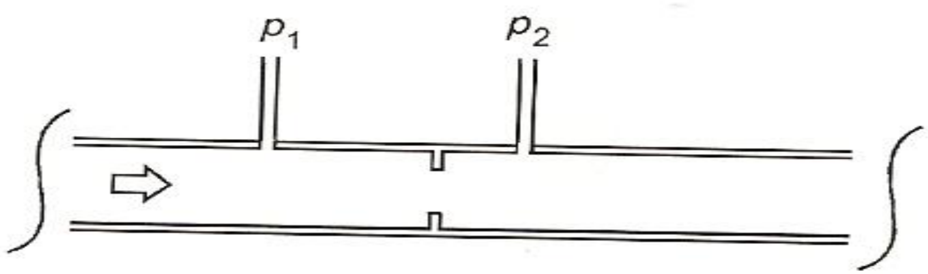
- Orifice plate
- Nozzle plate
- Venturi tube
- Pitot tube
- Ultrasonic
- Magnetic



a) Venturi



b) Nozzle



c) Orifice plate

$$Q = K\sqrt{\Delta p}$$

Q = volume flow rate

K = a constant for the pipe and liquid type

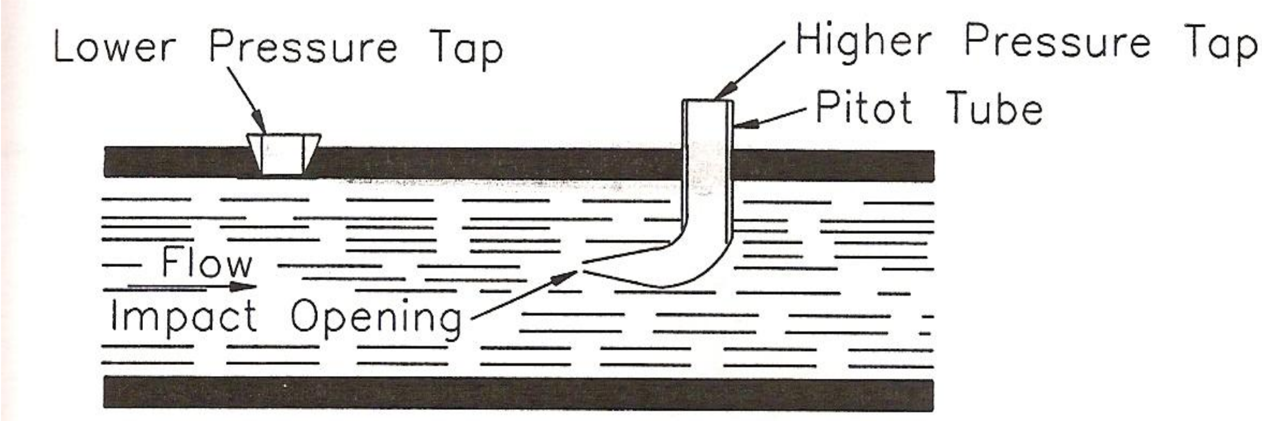
Δp = drop in pressure across the restriction

Volumetric flow rate = KAV

K = flow coefficient

A = Cross sectional area

V = Velocity of fluid



Ultrasonic

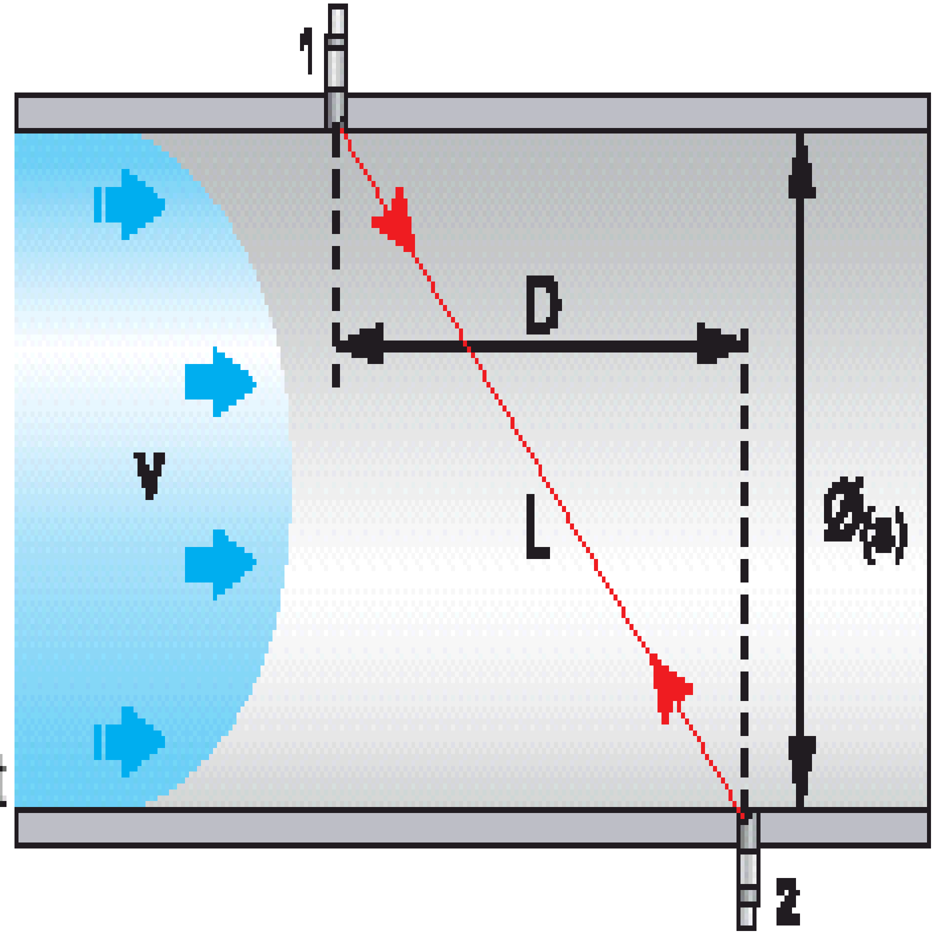
$\Delta t = t_{21} - t_{12}$

$$Q = \frac{\pi \text{Ø}^2_{(e)}}{4} \times \frac{L^2}{2D} \times \frac{\Delta t}{t_{21}\, t_{12}} \times \frac{1}{Kh}$$

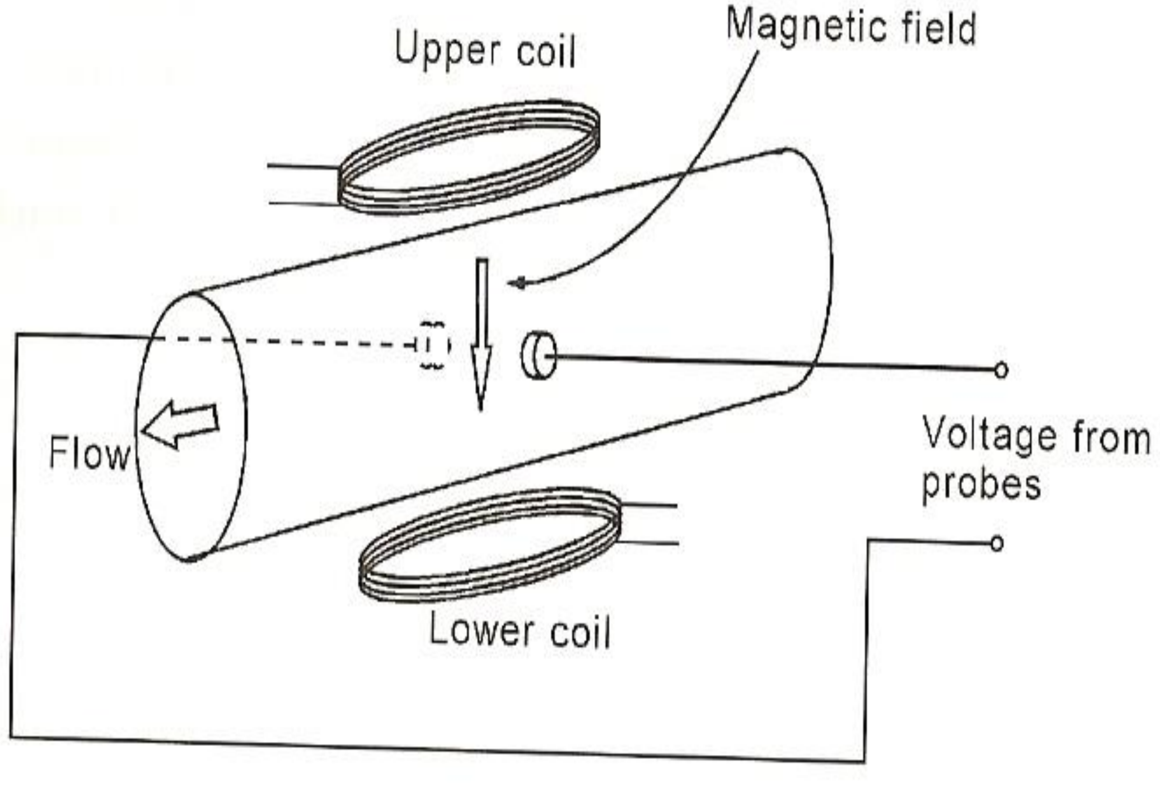
$Vol = Q \times t$

C : speed of sound in the fluid

Kh : hydraulic coefficient



Magnetic flow sensor



Level sensors

- Ball float
- Chain float
- Magnetic bond
- Conductive probe
- Wet reference leg

Ball Float

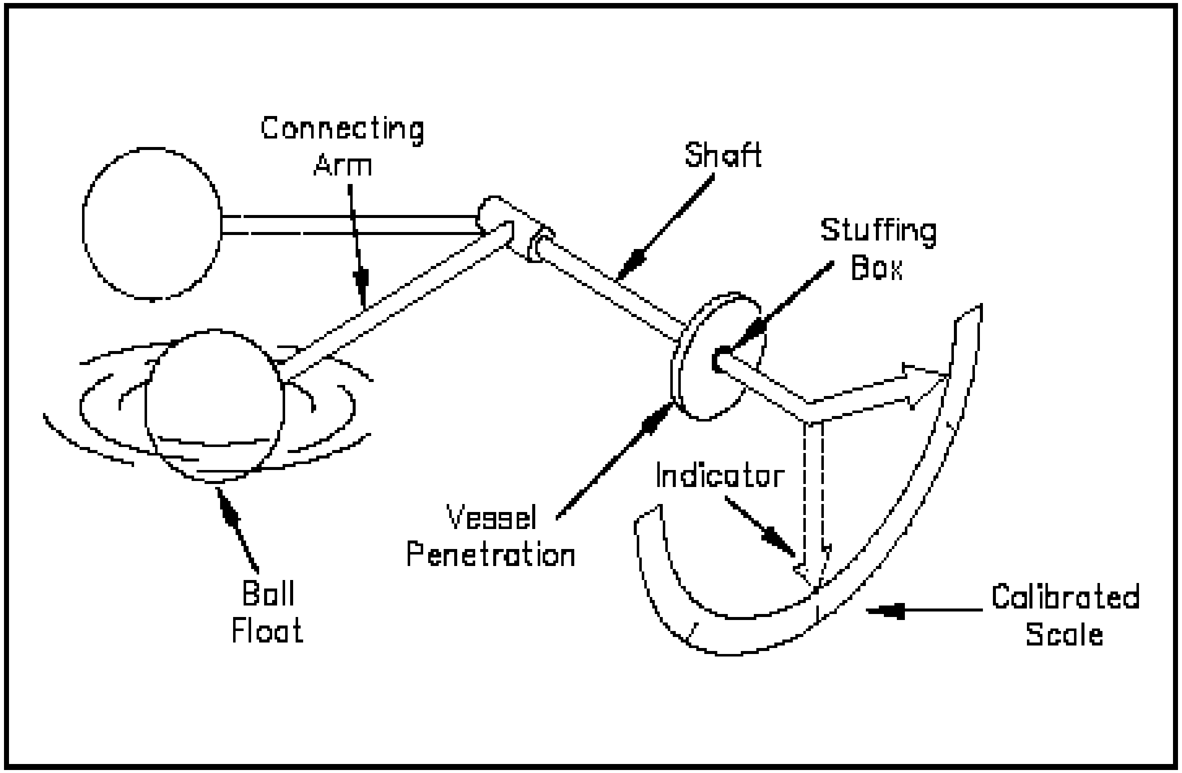


Figure 5 Ball Float Level Mechanism

Chain Float

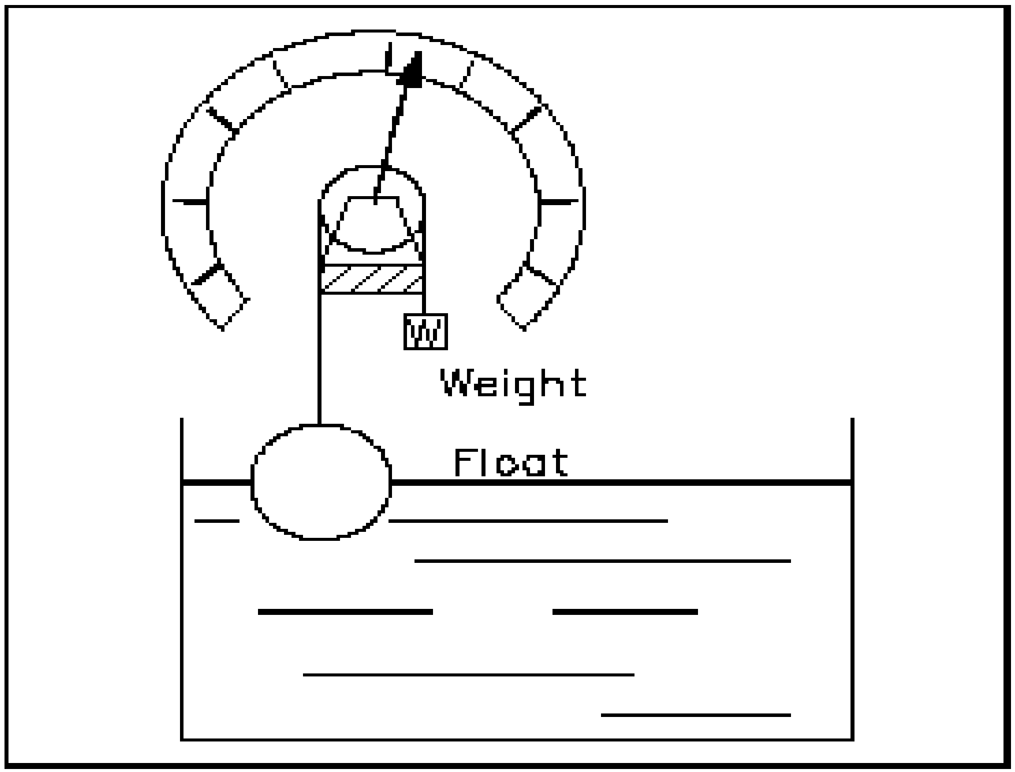


Figure 6 Chain Float Gauge

Magnetic

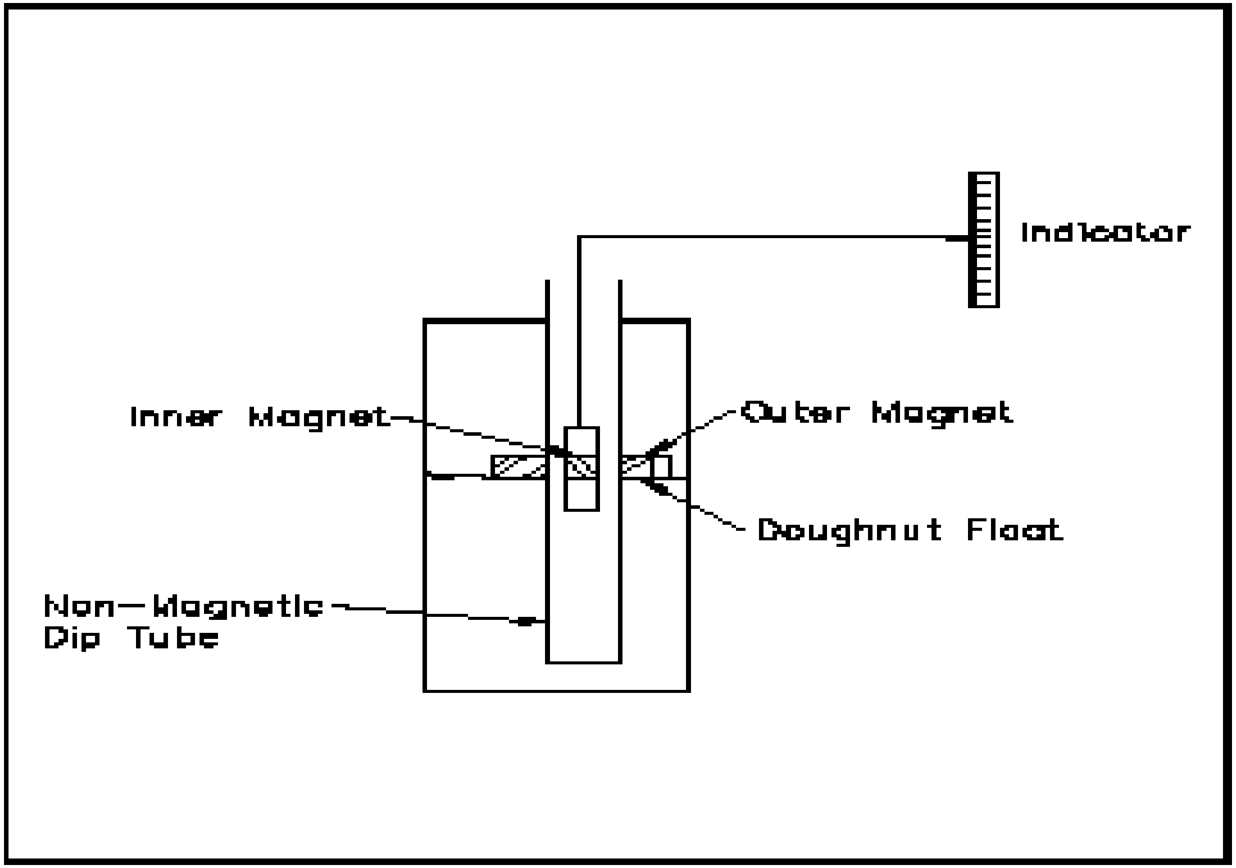


Figure 7 Magnetic Bond Detector

Conductivity Probe

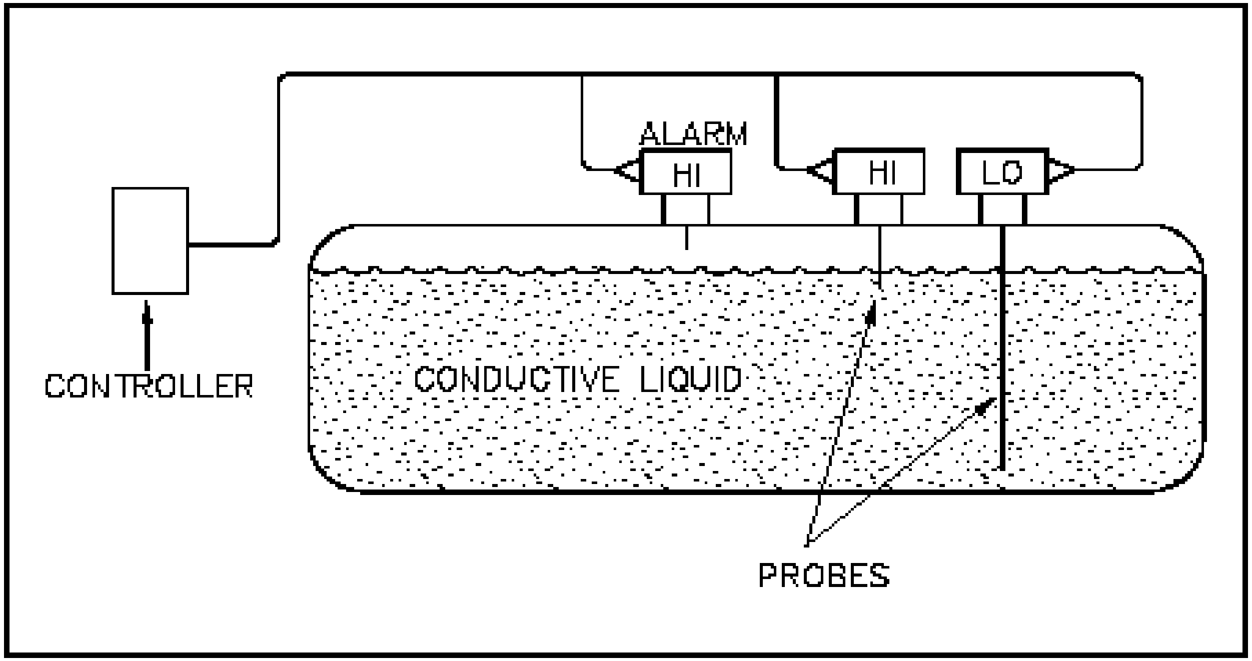


Figure 8 Conductivity Probe Level Detection System

Wet Leg Method

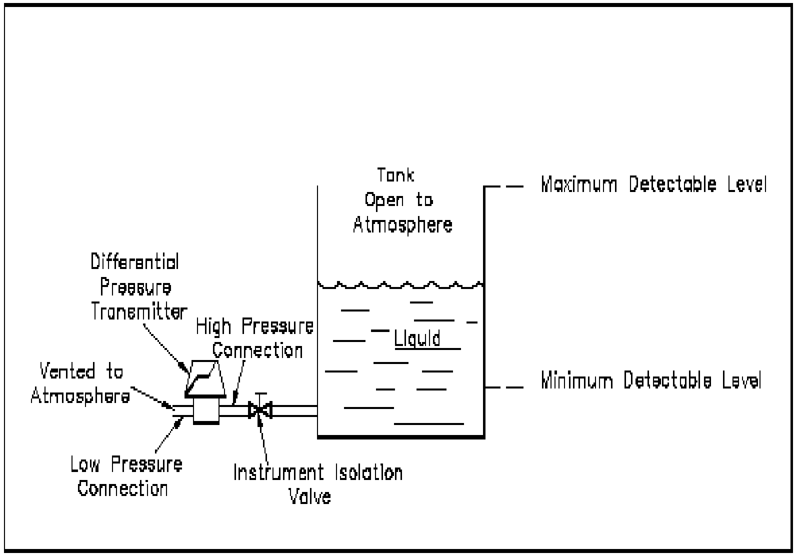


Figure 9 Open Tank Differential Pressure Detector

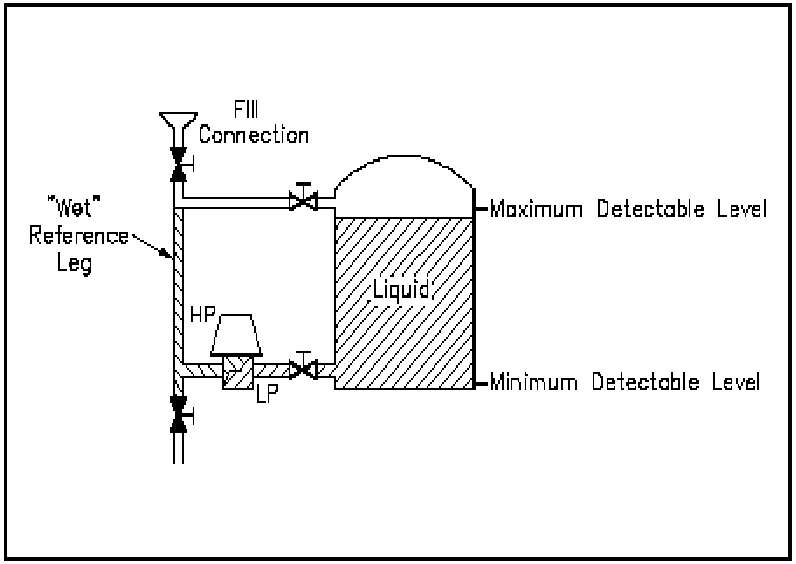
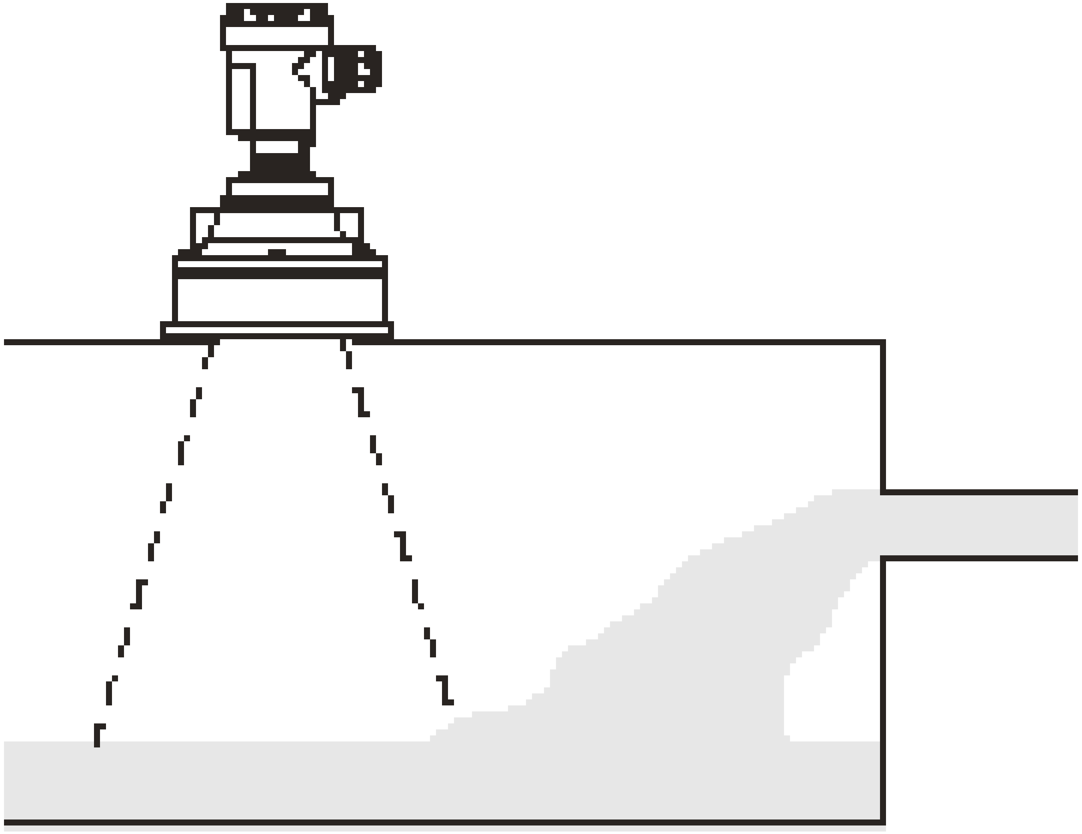


Figure 11 Closed Tank, Wet Reference Leg

Ultrasonic



Liquid bypass Level Indicator

Analyzers

- PH
- Conductivity
- Dissolved Oxygen
- Chlorine

PH Analyzer

- To determine the acidity or alkalinity of a solution
- pH = - $\log_{10}$ [H+] (hydrogen Ion)

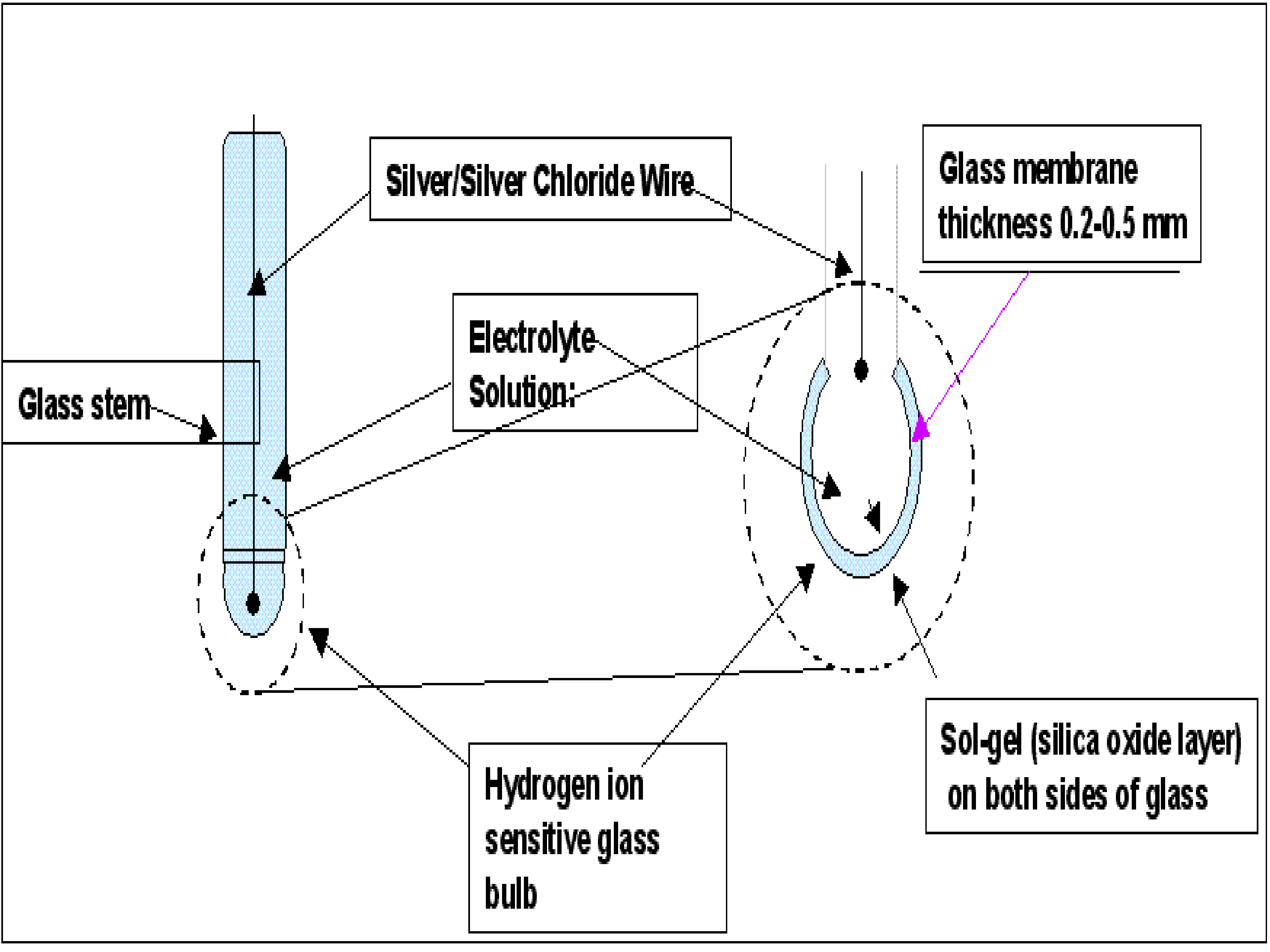
- The pH scale is derived from the dissociation constant of water in the following equation:

- **H2O -> H+ + OH- = 1 x 10-14 (mol/L)2 = Kw**
  (Kw is the dissociation constant of water).

Hydrogen Ion Concentration in Moles/Liter at 25° C		
pH	**H+ conc.**	**OH - conc.**
0	**1.0**	**0.00000000000001**
1	**0.1**	**0.0000000000001**
2	**0.01**	**0.000000000001**
3	**0.001**	**0.00000000001**
4	**0.0001**	**0.0000000001**
5	**0.00001**	**0.000000001**
6	**0.000001**	**0.00000001**
7	**0.0000001**	**0.0000001**
8	**0.00000001**	**0.0000001**
9	**0.000000001**	**0.00001**
10	**0.0000000001**	**0.0001**
11	**0.00000000001**	**0.001**
12	**0.000000000001**	**0.01**
13	**0.0000000000001**	**0.1**
14	**0.00000000000001**	**1.0**

Electrochemical Methods (pH electrodes)

- A pH Measuring System Consists of:
- A pH electrode
  - An electrode whose output voltage changes as the pH (hydrogen ion concentration) changes
- A reference electrode
  - An electrode whose voltage output stays constant
- A pH meter
  - A millivolt meter with a special high impedance input circuit and circuits to change the electrode's millivolts into pH unit readouts.
- An automatic temperature compensator,
  - A device which senses temperature so that the meter can correct for the effects of temperature changes.



Silver/Silver Chloride Wire
Glass membrane thickness 0.2-0.5 mm
Electrolyte Solution:
Glass stem
Sol-gel (silica oxide layer) on both sides of glass
Hydrogen ion sensitive glass bulb

pH vs. Temperature Error Chart

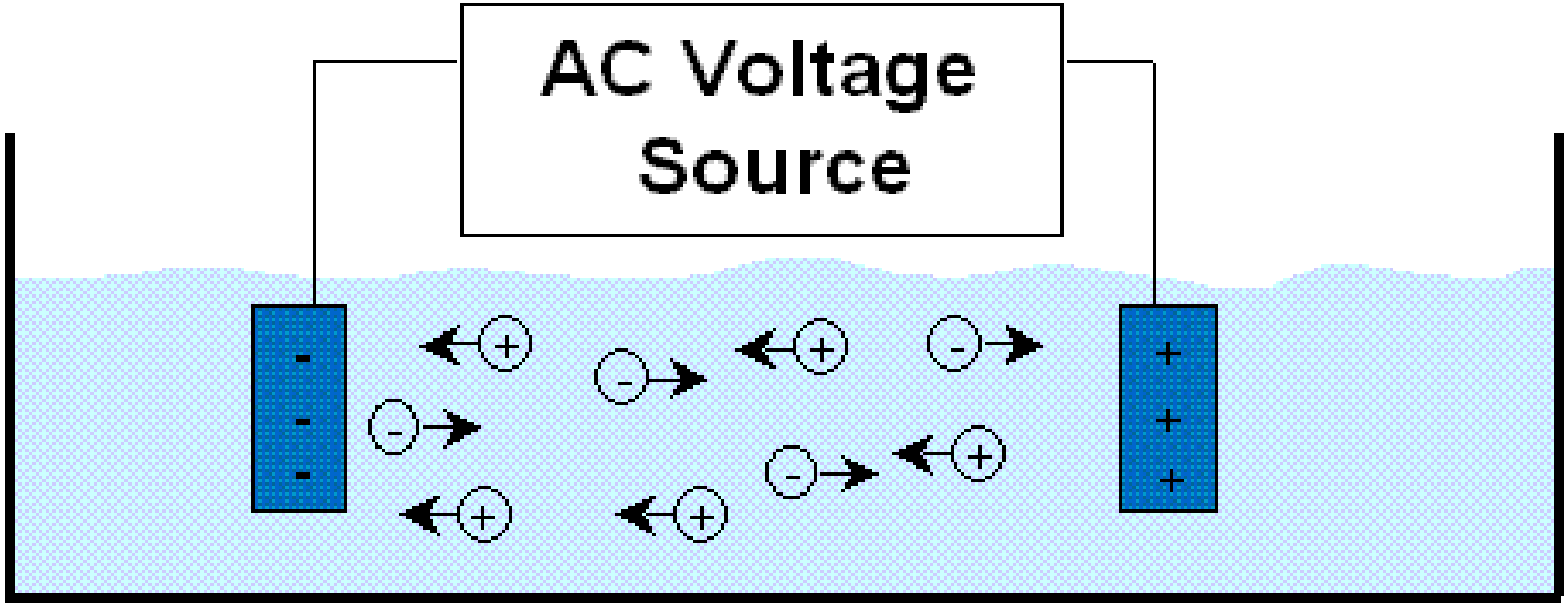
	pH 2	pH 3	pH 4	pH 5	pH 6	pH 7	pH 8	pH 9	pH 10	pH 11	pH 12
5°	.30	.24	.18	.12	.06	0	.06	.12	.18	.24	.30
15°	.15	.12	.09	.06	.03	0	.03	.06	.09	.12	.15
25°	0	0	0	0	0	0	0	0	0	0	0
35°	.15	.12	.09	.06	.03	0	.03	.06	.09	.12	.15
45°	.30	.24	.18	.12	.06	0	.06	.12	.18	.24	.30
55°	.45	.36	.27	.18	.09	0	.09	.18	.27	.36	.45
65°	.60	.48	.36	.24	.12	0	.12	.24	.36	.48	.60
75°	.75	.60	.45	.30	.15	0	.15	.30	.45	.60	.75
85°	.90	.72	.54	.36	.18	0	.18	.36	.54	.72	.90

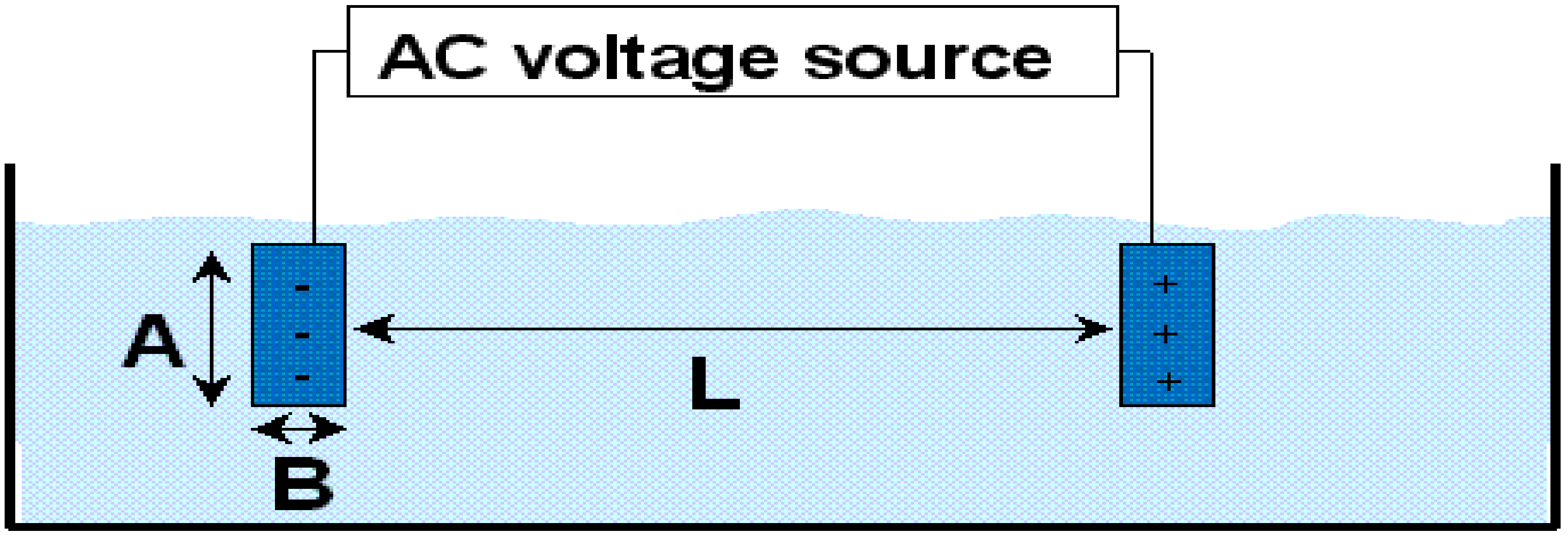
Conductivity Analyzer

- To measure the concentration of electrolytes in solutions
  - Acids
  - Bases
  - Salts
- Imposing a known voltage across two metal electrodes & measuring the current flowing between them.
- Components:
  - Electrode
  - Inductive
- Range of measurement
  - Pure water 0.55 uS/cn
  - Concentrated acids, bases & salts > 1000,000 uS/cm

Conductivity

- Conductivity is a measurement of the ability of a solution to conduct an electric current.
- Instrument measures conductivity by placing two plates of conductive material with know area and distance apart in a sample. Then a voltage potential is applied and the resulting current is measured.
- The number of ions that are conductive provides the conductive path between two electrodes of the conductivity cell. Higher ionic concentration yields higher conductivity.


AC Voltage Source


AC voltage source
A
B
L

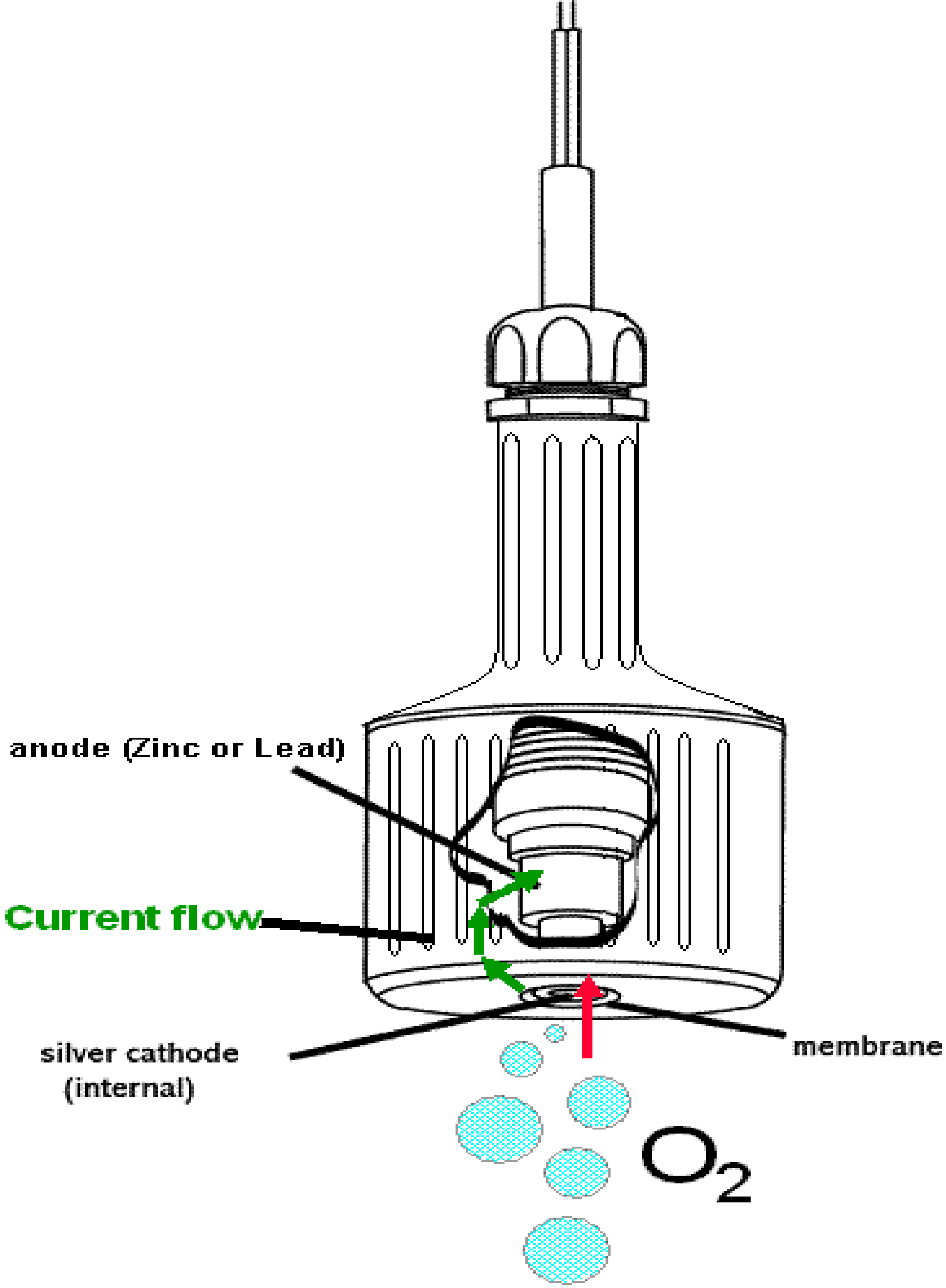
Resistivity (Ω)	Conductivity (μS)	ppm TDS
18,000,000	.056	.0277
12,000,000	.084	.0417
6,000,000	.167	.0833
1,000,000	1.00	.500
400,000	2.50	1.25
50,000	20	10
5,000	200	100
500	2,000	1,000
50	20,000	10,000

ppm = 0.64 x conductivity

Dissolved Oxygen

- Dissolved Oxygen (DO)
  - used for the measurement of the amount of oxygen dissolved in a unit volume of water
- Both probes use an electrode system where the DO reacts with the cathode to produce a current.
- If the electrode materials are selected so that the difference in potential is -.5 volts or greater between the cathode and anode, an external potential is not required and the system is called galvanic.
- If an external voltage is applied, the system is called polarographic.

- Galvanic DO sensors consist of two electrodes, an anode and cathode which are both immersed in electrolyte (inside the sensor body).
- **V = i x R**
- **R is resistance from thermistor in ohms**
- The thermistor corrects for membrane permeability errors due to temperature change.
- To represent sensor output in ppm or mg/L, the temperature of the water must be known. This is independent from the thermistor connected between the anode and cathode to compensate for membrane permeability changes due to temperature change.



anode (Zinc or Lead)
Current flow
silver cathode
(internal)
membrane
O_2

Chlorine

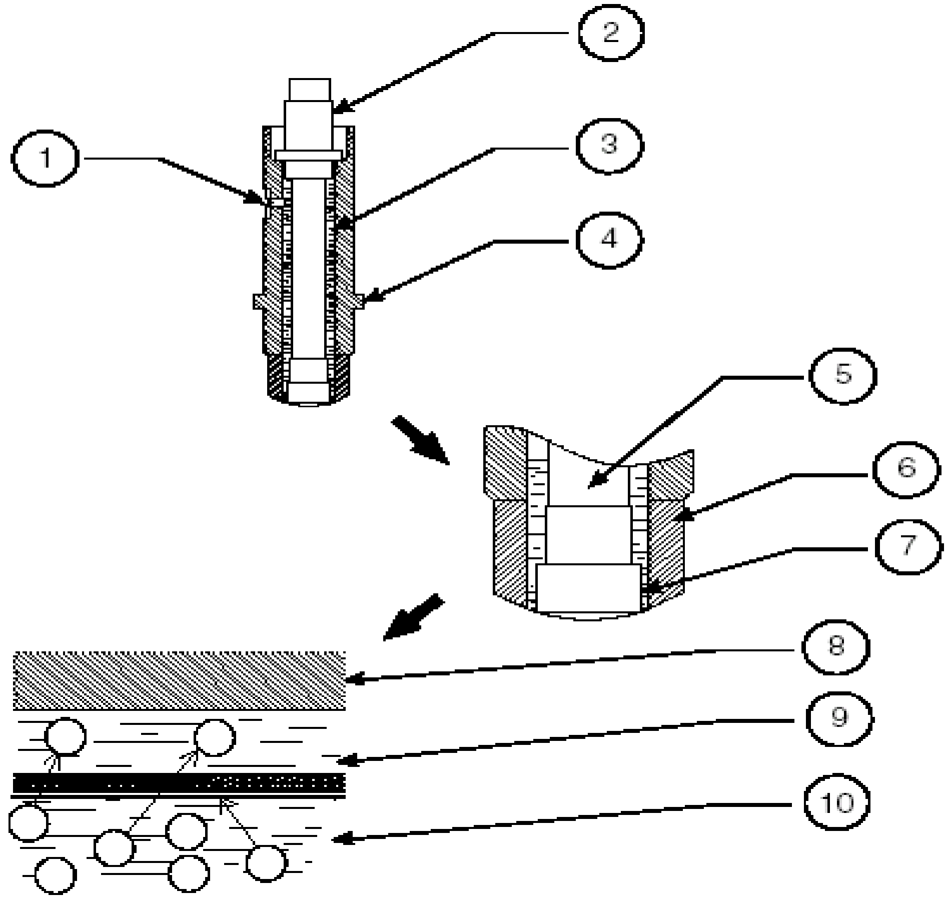
- The chlorine probe uses the principle of the Clark cell.
- The amperometric sensor consists of:
  - a gold working electrode where the main reaction occurs
  - a silver counter-electrode
  - KCl electrolyte
  - a microporous membrane selective to HOCl

- The HOCl molecules in the sample diffuse through the membrane to a thin region between the membrane and the cathode that contains the electrolyte.

- A constant potential is applied to the working electrode (cathode) where HOCl is reduced according to the reaction: $HOCl + (H^+) + (2e^-) \rightarrow Cl^- . H_2O$

- At the silver electrode (anode) the silver is oxidized to Ag^+:
- The reduction in HOCl at the cathode generates a current that is directly proportional to its partial pressure in the sample.

$$(2Cl^-) + (2Ag^+) \rightarrow 2AgCl + 2e^-.$$



1.	Electrolyte Filling Hole
2.	Assembled Electrode
3.	Electrolyte
4.	Probe Body
5.	Anode
6.	Membrane Holder
7.	Membrane
8.	Cathode
9.	Membrane Interface/Sample
10.	Sample