Concepts :-

Error :- it's the differance between the Results of the measurment and the value of the quantity to be measured.

Error types:
- ① controllable Error
- ② Random Error

$$Er_1 = \frac{Er_{FS} * FSD}{A_1}$$

Sources of Errors :-

- within operator variation.
- Between operators variation.
- Test equipment variation
- Material varaition.

controllable Error :- the Error that should not be occure, How ever, may be eliminated & corrected by more carful work & attention.

Random Error :- the Error that inherited in the measurment procces oR instrument.

Types of controllabe Error ⇒ Back To slides.

Accuracy :- Closeness of (measured value) to an accepted (standard value).

Static Error : difference between the measured value & the true value.

Static correction : " " " true value & the measured value

Back To calibration Def, Hysterises, Dead zone, Threshold, Resolution

over shoot : max. amount by which the pointer moves beyond the steady state.

Dead zone is the result of :-

1. friction.
2. Backlash.
3. hystrises in the instrument.

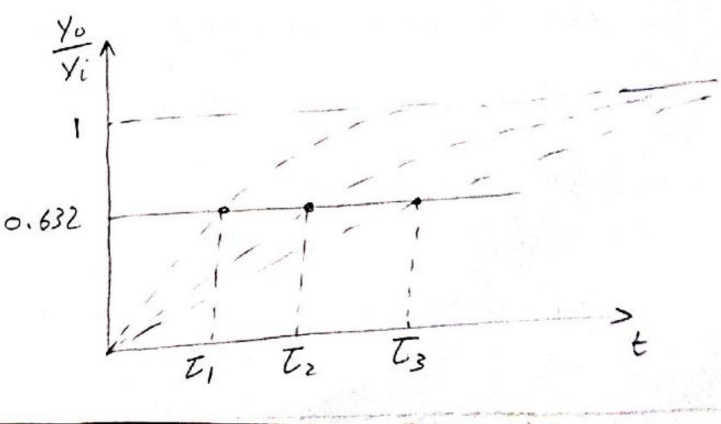
1^{st} order system :-

τ, should be minimize

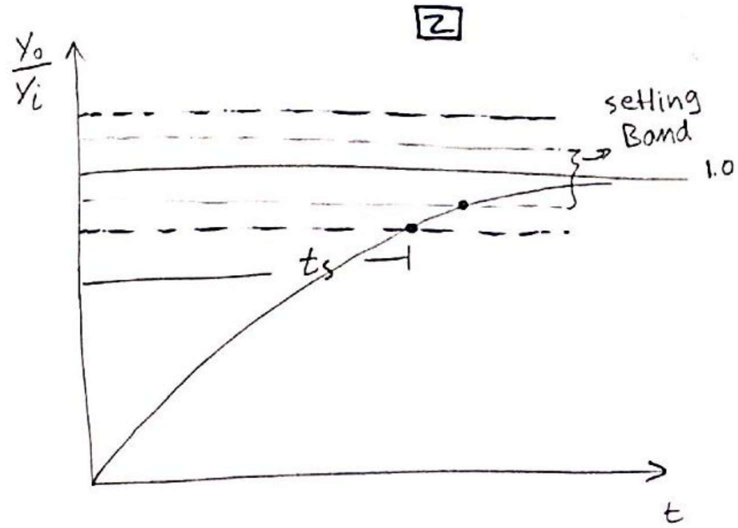
IF $\tau \uparrow$:- Error $\uparrow$

speed of response $\downarrow$

time of response $\uparrow$



setling Band ↑ , Error ↑
, t_s ↓



in Thermometer calculation (to find $\underline{\underline{I}}$ convert all dim. to $\underline{\underline{m^3}}$)

second order system :-

) rise time (t_r)
the time required for the response to rise from 0 to 100 % of its final value.

) peak time (t_P)
the time required for the response to reach the first peak of the over shoot.

setlling time (t_s)
the time required for the response to reach and stay within the range about the final value. (2% to 5%)

peak overshoot (M_P)
the max. peak value of the response curve measured from unity.

2^{nd} order , IF t_r ↓ → Error ↑ , t_s ↑ , t_P ↓ , M_P ↑
IF $E_s\%$ ↓ → t_s ↑

$t_r = \frac{\pi - \phi}{\omega_d}$ → Should be in $\underline{\underline{rad}}$

Main Functions of the Detector-transducer :-
1) sense the measurnd properly
2) convert the measurnd to a format acceptable by Intermediat stage.

Back To Transducer, dectector, Def. In Book.

3 types of potentiometer :-
① Linear (0.2 - 50) cm.
② Rotational (10-60°).
③ Helipot

Polintiometer :- Ideal $R_m = \infty$

Loading Error $R_m \downarrow$ ⇝ Error $\uparrow$

For Good V_o ⇒ increase V_i

For Error → 0 ⇒ use $R_m \uparrow$, $R_p \downarrow$

To solve power Rating problem, use:-
① Cermet.
② Carbon Film.
③ Hot moulded Carbon.

RTD & Thermister :-

→ used For Temp. measurment
→ measure "T" By observing Change in "R"

RTD	metal	use for high Temp.	$R_T \uparrow$ as $T \uparrow$
Thermister	semi conducter	use for low Temp.	$R_T \uparrow$ as $T \downarrow$

Material Properties :-
1- Linear R-T Relation
2- Non-Toxic
3- corrosive Risestance
4- uniform < composition. / Geometry.
5- $T_{max.working} > T_{melt\,point}$

⇒ RTD

α (+ve always) = slope × $\frac{1}{R_{T_0}}$. [Linear aprox.]

α_1 (+ve alwaye) }
α_2 (+ve OR -ve) } Quadratic approx.

⇒ Thermister {T should be Kelvin} ; In linear $R_T = R_{T_0}(1 + \alpha \Delta T)$

RTD يعني

piezoelectric :-

Natural → Quartz, → Rochelle salts } For Calibration

synthetic → Baruim Titanate (B.T), → Lithium sulphate (L.S) } For normal operations.

Material properties :-
1- high sensitivity
2- high purity
3- uniform < Geom. / composition
4- can be formed in multiple shapes.
5- Insensitive to change in T, humidity.

LVDT

#.

ADV.

1. low power consum.
2. less Friction
3. high sensitivity (40V/mm)

Dis.adv.

1. sensitive to any external mag. field.
2. performance is affected by vibration.

capacitor :-

distance (d) ↑ ⇒ C ↓ , sensitivites ↓

$$\text{Capacity Factor} = \frac{\frac{\Delta C}{C}}{\frac{\Delta d}{d} \text{ OR } \frac{\Delta L}{L} \text{ OR } \frac{\Delta W}{W} \text{ OR } \frac{\Delta A}{A}}$$

(choose the device which has higher capacity Factor).

Strain Gauge :-

* main type of strain Gauge :-

1. Bonded wire
2. Bonded Foil
3. Bonded semi conductor

* main configuration used for strain Gauge :-

1 - Linear strain Gauge
2 - RossEtto strain Gauge
3 - Helical strain Gauge

* Adhesives Examples :-

1. Epoxy cement
2. Bakelite cement
3. nitrocellulose cement

* Material properties.

1- Linear Relation Between $\in$ & R.
2- high Gauge factor.
3- high initial resistance.
4- Hystrises low as possible.

* Adhesives should be :-

1. non corrosive.
2. Should be quick drying type
3. insensitive To miosture to have a good adherence.

Flow Measurment :-

Flow meter classified to the following categories :-

1. Inferential type.
2. positive displacement type.
3. Mass Measurment type.

* Inferential methods for flow rate measu. :-

1. differential pressure meter.
2. magnetic meter.
3. Turbine meter.

* (venturi, oriffice, Flow Nozzle) :- obstruction Flow Techniques (أهمها)

* orifice plate, three locations of pressure taps :-

	Before	After
1- Flange tapes :-	25 mm	25 mm
2- Vena contracta. tapes :	D	D
3- Raduis taps :-	D	$\frac{1}{2}$ D

μ : Dynamic visc
ν : Kinematic viscosity.

Dis. Adv. of orifice

1. high pressure loss.
2. low value of Discharge coeff.
3. Cavetation.

Adv.

1. low initial cost.
2. require less space than venturi.

- venturi meter

Location of pressure taps :- at throat and at entrance where the venturi has diam. equal to the pipe diam.

Dis. adv.

1. high initial cost
2. need to long (large) space
3. construction insid the pipe is deficult

adv.

1. Low pressure loss (Error small)
2. high value C_D

	venturi	Flow Nozzle	orifice
pressure loss	Lowest	Lower than orifice	highest
C_D	highest	lower than venturi	lowest
space	Long	lower than venturi	small
initial cost	highest	lower than venturi	lowest
construction	Difficult	lower difficulty than venturi	easy

* Meter selection depend on:-

1- cost 2- placement available 3- Accuracy.

4- Nature of flow.

accuracy depend on :-

- Density of flow (ρ)
- Diameter ratio (β)
- Discharge coeff. (C_D)

Hot-wire Anemometr : measure fluid velocity By noting the heat convected away by the fluid.

Hot wire made By :-

- platinum
- Tungesten

* Hot wire protected By :-

1- Hollow glass tube
2- quartz fiber.

2 types of Hot wire Anemometer :-

1- constant - current
2- constant - Temperature. الاشهر

* Adv.

1. Excellent Resolution.
2. High response

* Dis. adv.

1- used only in clean Gas flows
2- High cost
3- need to recalibrated frequently due to dust accumulat
4- ΔT should be higher than 8 C°

pitot tube :-

use to measure velocity

Disadv.

① Flow should be clean & straight
② sensitive for flow type.

Flow Device calibration :-

Device :- Flow prover.

principle work :- catch & weight.

Temperature Measurment

- Error in Temperature measurment :-

1- Change in T_{atm}.
2- change in T (specimines).
3- Thermal lag (non-equibruim).
4- Transmission loss.

Bimetalic :-

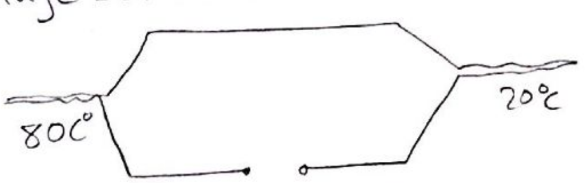
* conv. $\Delta T \rightarrow \Delta L$
* this device only which use to : Temp. measurment & control.
* we have 2 configuration :-
 1- Free ends.
 2- cantilever (fixed) end

Thermo couple :-

→ voltage inside circuit :-
① peltier emf : @ Hot Junction due to temperature rise.
② Thomson emf : due to tempreture diff. Between Ends.

→ Thermo couple principles

1. T.C must contain at least 2 diff material & 2 Junctions.
2. v_o depend only on the diff. between two Junction Temp. $(T_2 - T_1)$
3. (Low of intermediat metal) :- IF metal C insert to thermo.couple curcuit, the v_o is not affected IF maintianed at the same temp.
4. insert metal C in Junc. 1, v_o is not affected IF :-
 1. $T_{AC} = T_{BC}$ (uniform Temp.)
 2. voltage Between two Junction in equilibruim
5.



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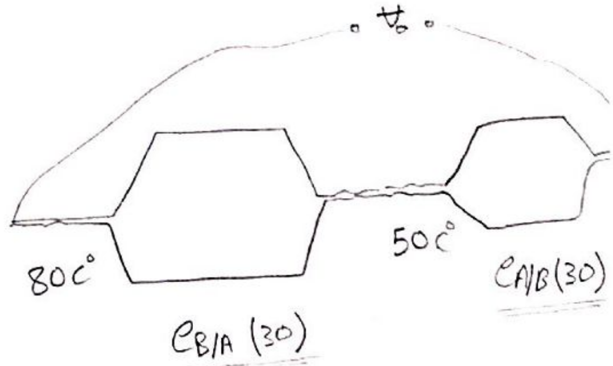


6. $v_o = e_{B/A}(60)$

Pressure measurment :-

- Device: Bourdon tube

- Bourdon configuration :-
1) spiral
2) Helical
3) Twisted tube
4) C-type

- ارجع الى كمية الاجزاء

- why use oval cross section ??

To damping Extra pressure By change diameter.

- material properties :-
1- uniform cross section
2- Pure metal
3- Ductile material
4- high conductive material.
5- smooth surface.

pressure Calibration :-

2 Devices → precision manometer. / Dead weight tester.

manometer

$K_s = \frac{1}{2\rho g} = \frac{1}{2\gamma}$

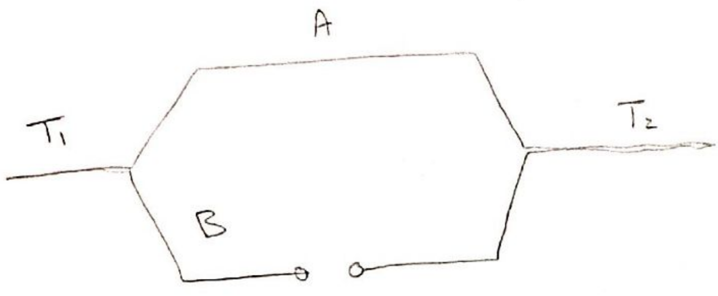
IF $\gamma \uparrow$, $K_s \downarrow$

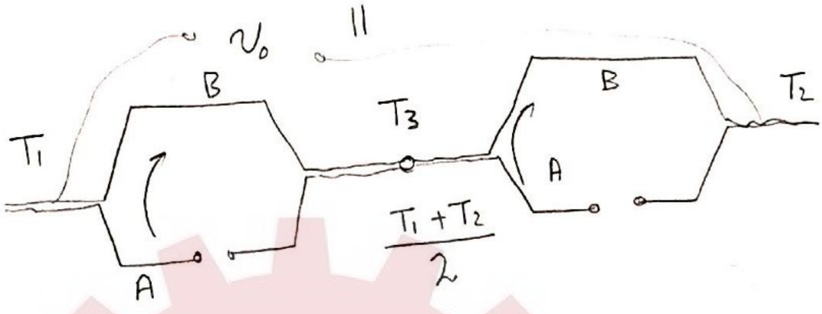
- To solve accuracy problem In manometer :-
1) use Anti parallax
2) laser
3) ultra sonic
4) Ball manometer

- Dead weight Tester :-

Device use calb. :-
1) mano meter
2) pezo electric

- the following act on the calb. procces
1) Room Temperature
2) oil viscosity.





$$v_o = v_{o(1-3)} + v_{o(3-2)}$$

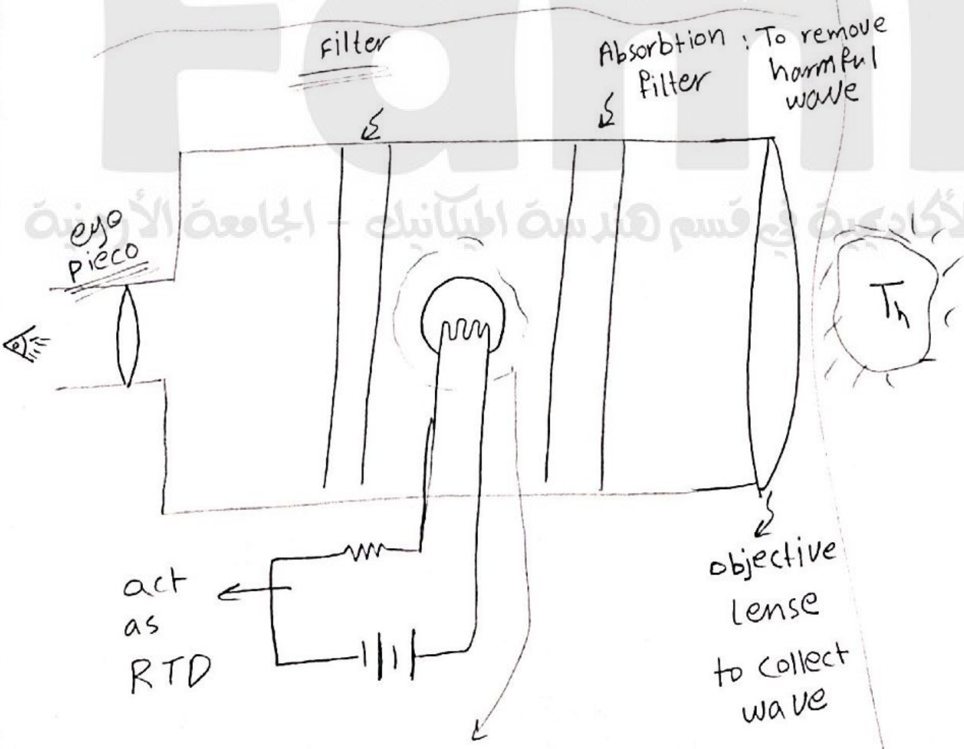
$$v_{o(1-3)} = e_{A/B}\, T_1 + \cancel{e_{B/A}\, T_3}$$

$$v_{o(3-2)} = \cancel{e_{A/B}\, T_3} + e_{B/A}\, T_2$$

Because $e_{B/A} = -e_{A/B}$

$$v_o = v_{o(1-3)} + v_{o(3-2)} = e_{A/B}\, T_1 + e_{B/A}\, T_2$$

$$\boxed{v_o = e_{A/B}\,(T_1 - T_2)}$$



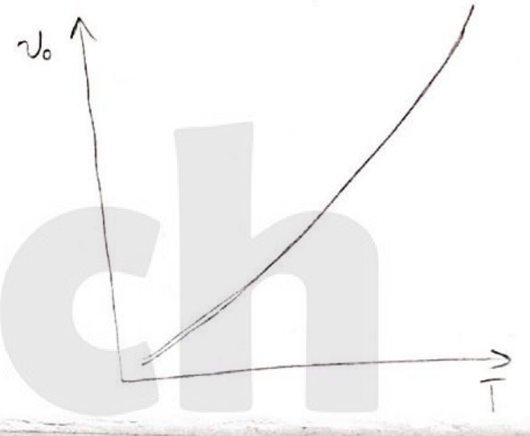
Thermo couples

Def. is simple temperature sensor contains at least two different material & two Junctions.

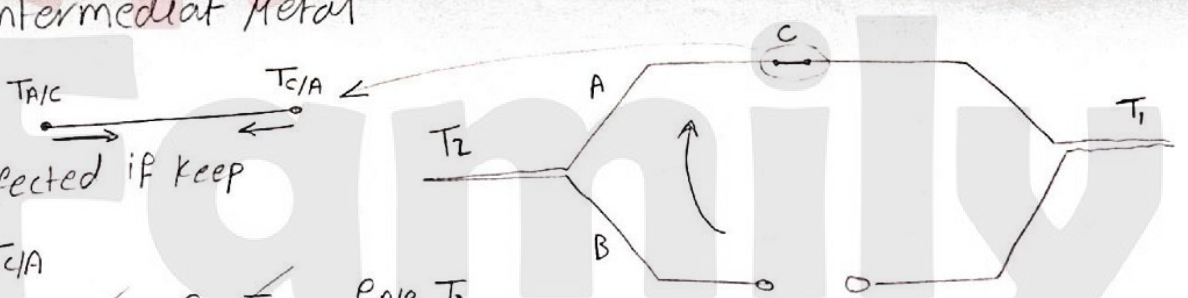
Junction types
1) twisting wires together
2) By welding
لحام
3) by soldering
X لحام
4) brazing two materials together

seebeck effect Appility of metal to convert Temp. difference into voltage.

$$\boxed{v_o = C_1(T_1 - T_2) + C_2(T_1^2 - T_2^2)}$$



* low of intermediat Metal

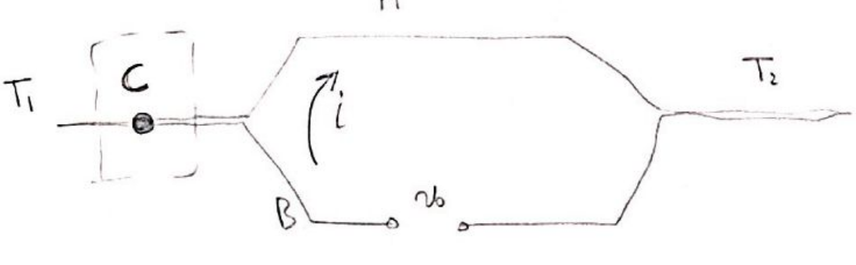


v_o is not effected if keep

$T_{A/C} = T_{C/A}$

$v_o = e_{B/A} T_2 + \cancel{e_{A/C} T_{A/C}} + \cancel{e_{CA} T_{C/A}} + e_{A/B} T_1$

$v_o = e_{B/A}(T_2 - T_1)$



$v_o = e_{BC} T_1 + e_{CA} T_1 + e_{AB} T_2$

$e_{BA} = e_{BC} + e_{CA}$

$\therefore v_o = e_{BA} T_1 + e_{AB} T_2$

$= e_{BA}(T_1 - T_2)$