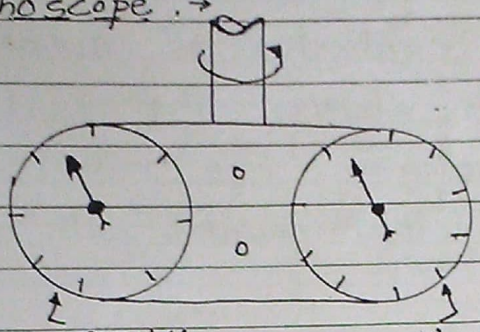
rotational speed rather than an instantaneous rotational speed.

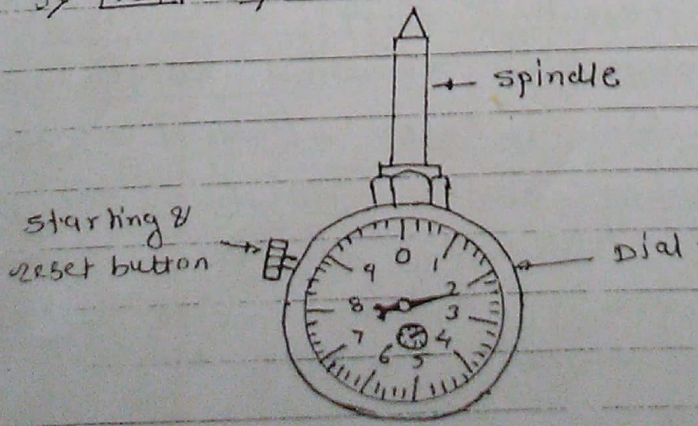
- This type is used upto 2000 - 3000 rpm.

2) Tachoscope :-



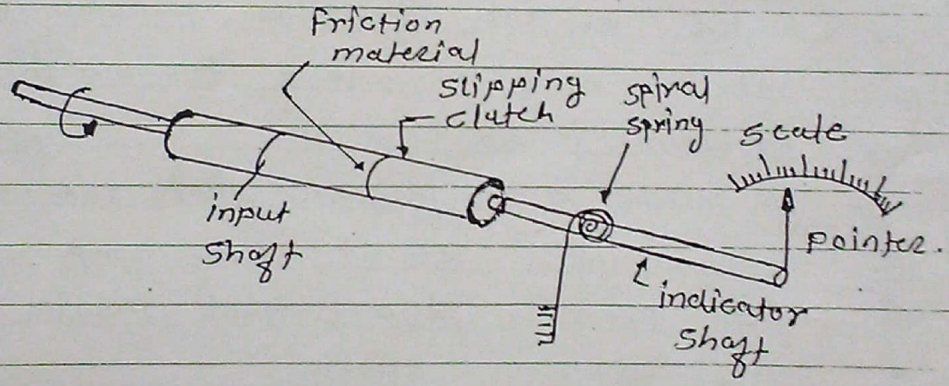
- The main difficulty in revolution counter is regarding, the operation of starting and stopping stop watch simultaneously with counter is not feasible practically.
- But by making use of tachoscope, this problem is solved.
- In such arrangements both the stop watch and counter start and stop simultaneously with pressing of a contact point against the rotating shaft.
- Tachoscope is used to measure upto 5000 rpm.

3) Hand Speed indicator :



- It consists a spindle, which can be attached to the object whose speed is to be measured.
- The spindle is connected to mechanical counters which display the count.
- This type of indicator has inbuilt stop watch and a mechanical counter with automatic disconnect.
- The hand speed indicator can be used upto speeds 20,000 to 30,000 rpm

4) Slipping clutch Tachometer:



construction:→

It consists of a driving shaft which drives the indicating shaft.

A pointer is attached to the indicating shaft, to which is also attached spiral spring.

A slipping clutch attaches the driving shaft and indicating shaft.

There is a calibrated scale on which the pointer moves.

operation:→

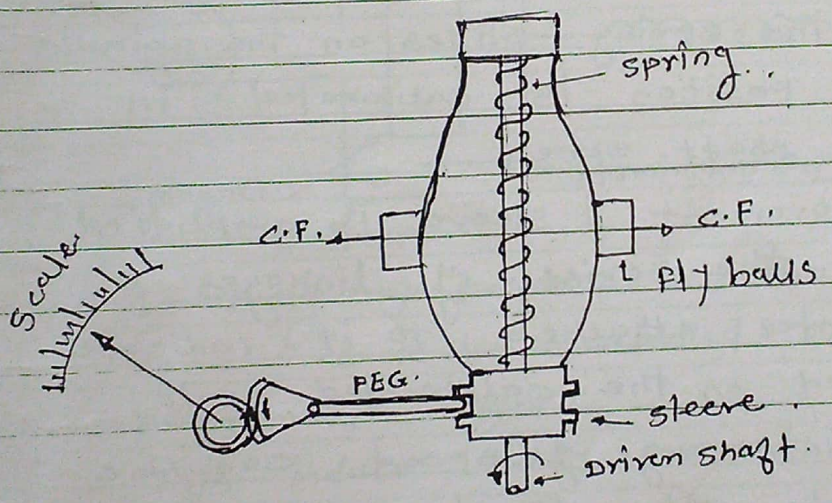
- The indicating shaft is driven by the driving shaft through the slipping clutch.

- The pointer attached to the indicating shaft shows the reading on the calibrated scale.
- The pointer moves against the torque of spiral spring attached to the indicating shaft.
- Thus, the reading shown by the pointer on the calibrated scale is the measure of the shaft speed.

5) centrifugal force tachometer

OR

flyball type mechanical tachometer



Principle :→

centrifugal force is proportional to the speed of rotation.

construction :→

Two fly balls (small weights) are arranged about a central spindle.

A grooved sleeve attached to the free end of the spring and slides on the spindle.

The movement of sleeve is magnified and attached to the pointer, which indicates the speed of the shaft on the calibrated scale.

Working :-

- The two flyballs are arranged so as to generate the centrifugal force and compress the spring as a function of rotational speed.
- The sleeve attached to the free end of the spring slides on the spindle and it's position is calibrated in terms of shaft speed.
- The movement of sleeve is amplified through the series of linkages & the pointer attached to it indicate the speed on the calibrated scale.
- The wide range of speed can be measured with the help of centrifugal force tachometer.
- Centrifugal tachometers are frequently used to measure rotational speeds upto 40,000 rpm with an accuracy of about ±1%.

5

* Electrical Tachometer

An electrical tachometer depends for its indications upon an electrical signal generated in proportional to the rotational speed of the shaft.

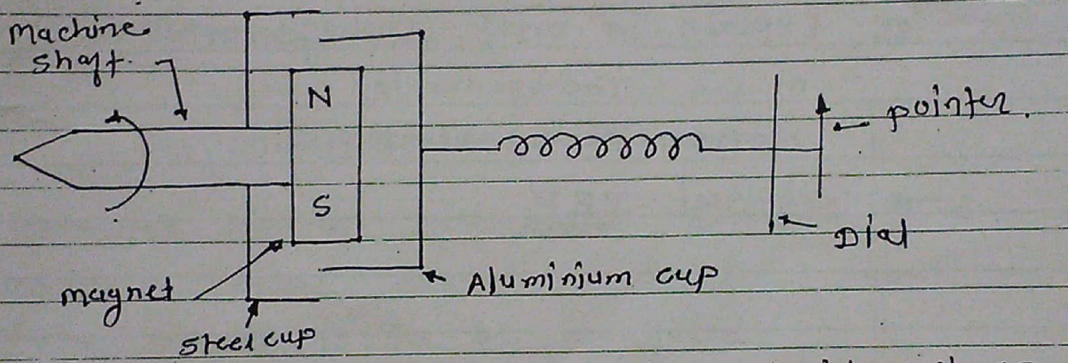
Imp

1) Drag cup tachometer

OR

Que: Sketch & explain the working of typical Speedometer used in motor vehicles.

(Drag cup tachometer)



- In Drag cup tachometer, the shaft whose speed is to be measured rotates the permanent magnet.
- This induces eddy current in a drag cup or disc held close to the magnet.
- The eddy current produce a torque which rotates the cup against the torque of a spiral spring.
- The disc turns in the direction of magnetic ~~magnetic~~ field until the torque developed equals to that of the spring.
- The pointer attached to the cup indicates the rotational speed on a calibrated scale.

- The automobile speedometer operates on this principle to measure the angular speed of wheels.
- These tachometers are used for measuring rotational speeds upto 10,000 rpm with accuracy of ± 3%.

2) Tachogenerator.

or Explain in brief tachogenerators.

a) DC Tachogenerator

b) AC Tachogenerator.

→ referred VBD.

* Non-contact type electrical tachometer:

In this type of tachometers, a pulse is generating without any direct contact between the rotating shaft and the speed transducer.

emf

1) Inductive pick-up tachometer:

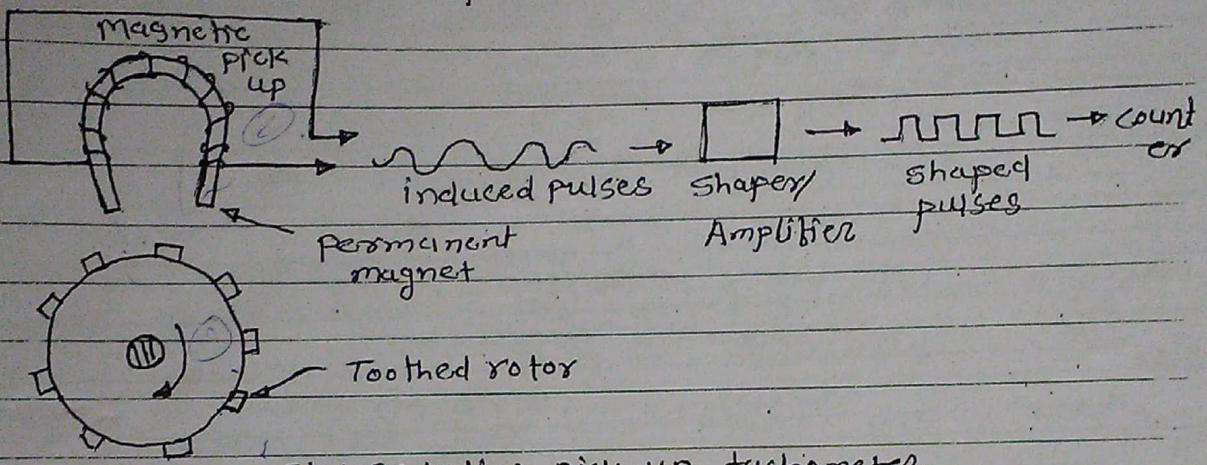


Fig: Inductive pick-up tachometer.

i) Inductive pick-up tachometer consists of a metallic rotor mounted on the shaft whose speed is to be measured.

ii) A magnetic pick up is placed near the toothed rotor.

iii) A magnetic pick up consists of a housing containing a permanent magnet with a coil wound round it.

iv) When the rotor rotates, the reluctance of the air gap between pick up and the toothed rotor changes giving rise to an induced emf in the pick up coil.

v) This output is in the form of pulses, with a variety of wave shape.

vi) The frequency of the pulses of induced voltage will depend upon the number of

teeth of the rotor and its speed of rotation.

vii) As the number of teeth is known, the speed of rotation can be determined measuring the frequency of pulses with an electronic counter.

Let,

Number of the teeth on rotor = T

Number of revolution = N

Number of pulses/sec = P

∴ Speed 'N' is given by.

$$\text{Speed } N = \frac{\text{Pulses per second}}{\text{Number of teeth}}$$

$$N = \frac{P}{T} \text{ rps}$$

$$N = \frac{P}{T} \times 60 \text{ rpm.}$$

If the rotor has number of teeth equal to '60' then counter will display directly the speed.

Advantages:→

i) It is simple & rugged in construction.

ii) It is maintenance free.

iii) It is easy to calibrate.

8

W2

Imp

Capacitive pick up tachometer:

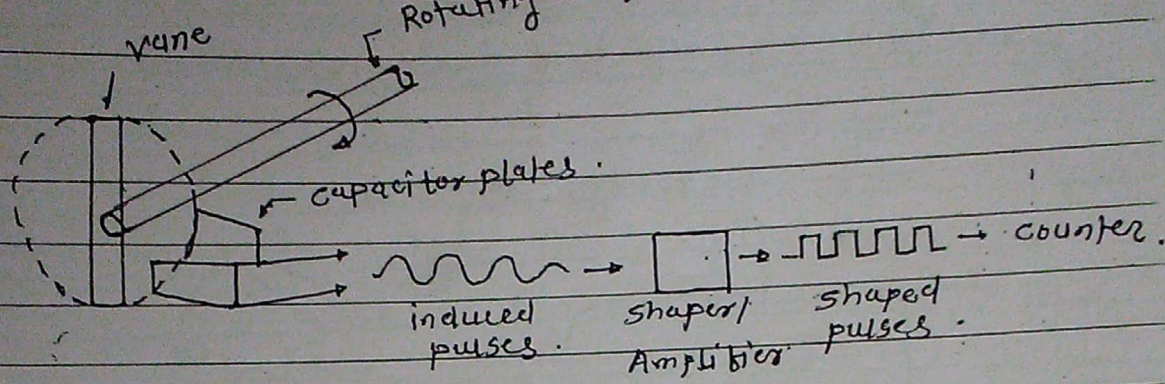


Fig: capacitive pick-up tachometer.

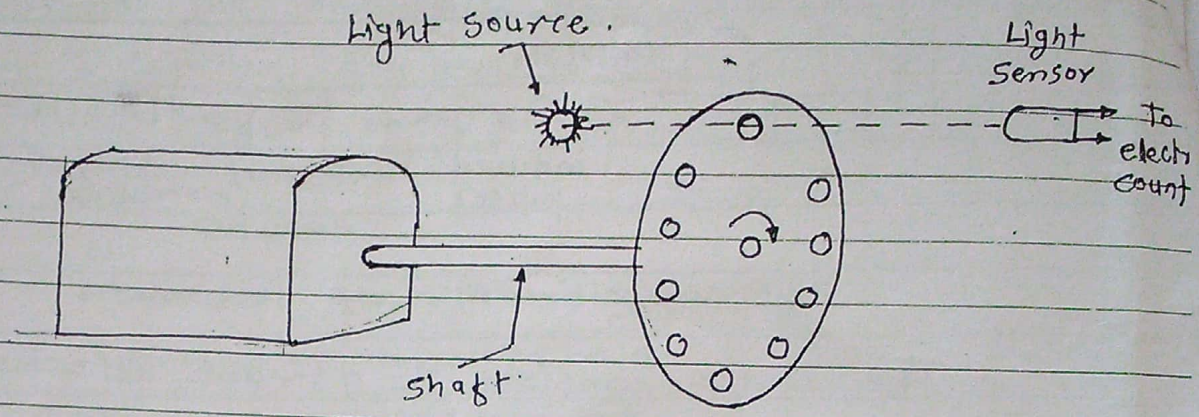
- The device consists of a vane attached to one end of the rotating machine shaft whose speed is to be measured.
- The two plates are placed on either side of vane, forming a capacitor.
- When the shaft rotates between the fixed capacitive plates, there occurs a change in the capacitance.
- The capacitor forms a part of an oscillator bank so that number of frequency changes per unit of time is a measure of the shaft speed.
- The pulses thus produced are amplified and squared and may then be fed to frequency measuring unit or to a digital counter so is to provide a digital analog of the shaft rotation.

Advantages:-

i) High sensitivity.

ii) It has very small loading effect.

* photo-electric tachometer:



i) This method of measuring speed of rotation consists of mounting an opaque disc on the rotating shaft.

ii) The disc has a number of equidistant holes on it's periphery.

iii) At one side of the disc a light source is fixed and at the other side of the disc and in line with light source, a light sensor such as photo tube is placed

iv) When the opaque portion of the disc is betn the light source and the light sensor, the latter is unilluminated and produces no output.

v) But when a hole appears betn the two, the light falling upon the sensor produces an output pluse.

vi) The frequency at which these pulses are produced depends upon the number of holes in the disc and it's speed of rotation.

vii) As the number of holes is fixed, the pulse rate is function of speed of rotation

viii) The pulse rate can be measured by an electronic counter which can be directly calibrated in terms of speed in rpm.

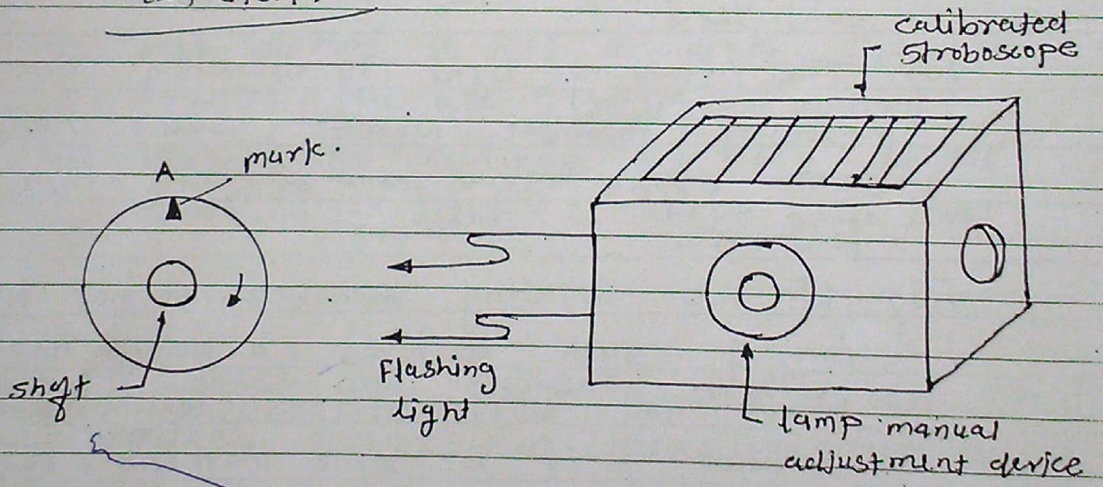
Advantages:

i) Simple in construction.
ii) The output is in digital form.
iii) Easy to operate and understand.
iv) Less maintenance.

* Stroboscope: W-2

OR

Que: Suggest and explain the device used for the measurement of high speed of rotation.



i) The use of stroboscope method depends upon imperfect dynamic response of human eye.
ii) The stroboscope is a simple, portable manually operated device which may be used for measurement of periodic or rotary motions.
iii) Basically, the instrument is a source

of variable frequency flashing brilliant light, the flashing frequency being set by operator.

iv) An oscillator is provided so that the moving object is visible at specific intervals.

v) If strong light is caused to flash on moving object, the object will appear stationary.

vi) The stroboscope consists of a source of flashing light whose frequency can be varied and controlled.

vii) The flashing light is directed on rotating member, which usually has some spoke, gear teeth or some other features.

viii) If the rotating member do not have any of such features, a paper having black and white stripes, which is attached to it or some marking is done at a target.

ix) The frequency of lamp flashing is adjusted until the target appears stationary.

x) Under this condition, speed is equal to flashing frequency. The scale of stroboscope can be calibrated to read the speed directly.

$n = f$ where n = speed of shaft

f = flashing frequency.

Advantages:

i) It requires no special attachment with the shaft.
ii) This method imposes no load on shaft.
iii) It is very convenient to use a stroboscope for spot check on machinery speeds and for laboratory work.
iv) This method is particularly useful where it is impossible to make contact with the shaft.

Limitations:

i) variable frequency of oscillator can not be stabilized to give fixed frequency.
ii) This method is less accurate therefore requires the use of digital meters.
iii) stroboscope can not be used where surrounding light is above some level.

xi) If there are several marks on shaft, various errors in measurement arises.
xii) If disc has 'm' number of marks, then disc will appear stationary.

$$\text{The speed } (n) = \frac{f}{m}$$

where f = Number of flashes per sec
m = Number of marks on disc.

* Non-contact type electrical tachometer:

In this type of tachometers, a pulse is generating without any direct contact between the rotating shaft and the speed transducer.

1) Inductive pick-up tachometer:

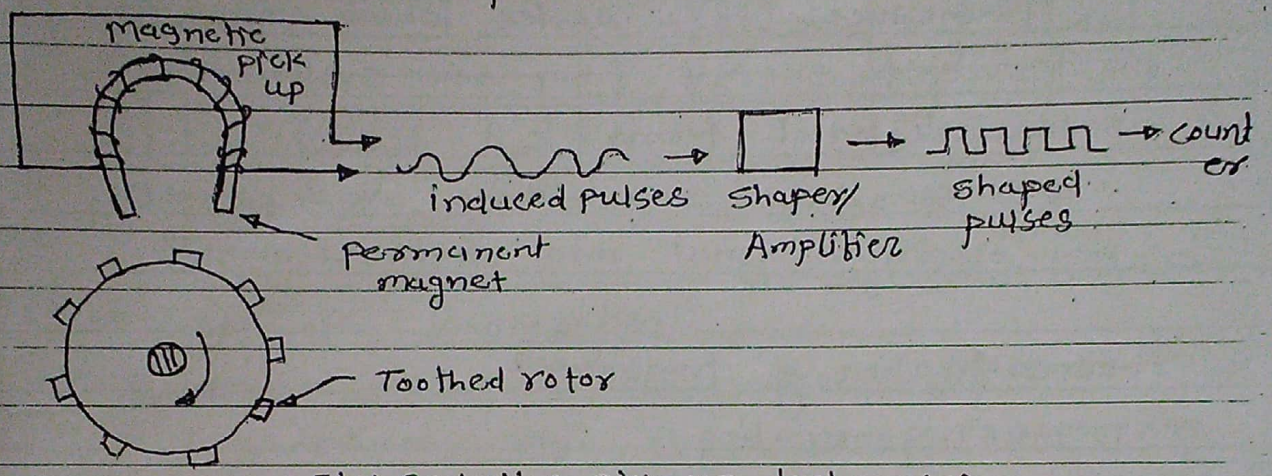


Fig: Inductive pick-up tachometer.

i) Inductive pick-up tachometer consists of a metallic rotor mounted on the shaft whose speed is to be measured.

ii) A magnetic pick up is placed near the toothed rotor.

iii) A magnetic pick up consists of a housing containing a permanent magnet with a coil wound round it.

iv) When the rotor rotates, the reluctance of the air gap between pick up and the toothed rotor changes giving rise to an induced emf in the pick up coil.

v) This output is in the form of pulses, with a variety of wave shape.

vi) The frequency of the pulses of induced voltage will depend upon the number of

* Measurement of Angular & Linear displacement.

* Transducer:

"Transducer is a device which converts the received energy from one system to usable different forms."

"Transducer is a device which converts non-electrical signal into electrical signal".

* classification of transducer:

1) Self-generating :-

- These type of transducers does not require any external power source for their operation.
- The energy required for this is absorbed from the physical quantity being measured.
- They develop their own output voltage.
- They are also called as active transducer.
- Example: i) piezo electric pick up
  ii) Thermocouple.
  iii) photo-voltaic cell.

2) Non-self-generating :-

- These type of transducers require an external power source for their operation.
- They are also called as passive transducer.
- Example: i) potentiometer.
  ii) strain gauge
  iii) LVDT
  iv) RTD

Imp.

* LVDT or Linear variable differential Transducer (Linear measurement).

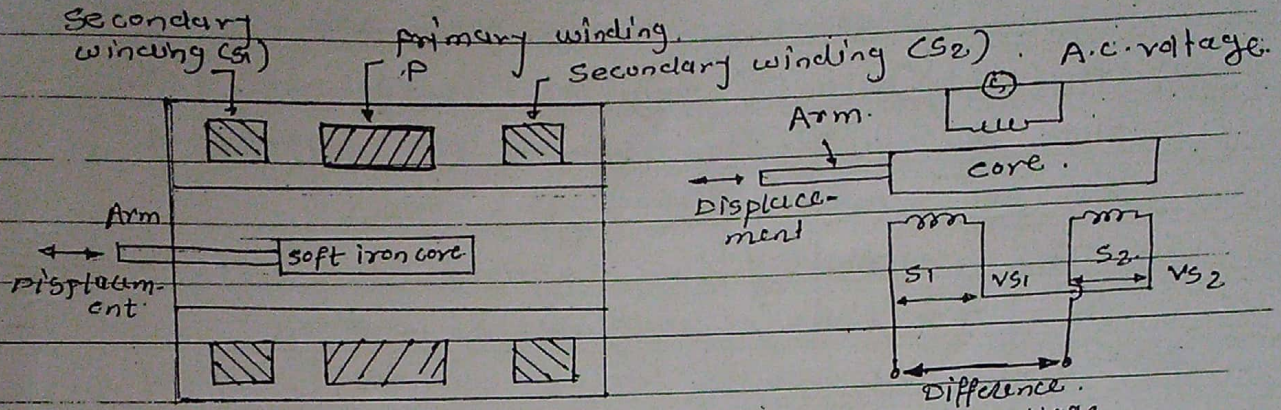


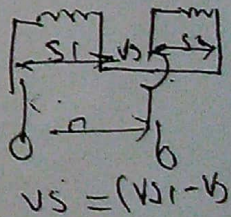
Fig: LVDT

Fig: circuit connection.

construction & operation:

i) LVDT means linear variable differential transducer. this is a non-self-generating transducer which required a external source for their operation.

ii) The device has one primary and two secondary windings with the magnetic core free to move inside the coils.



iii) The core is attached to the moving part on which the displacement measurements are to be made.

iv) When a.c. current is supplied to the primary winding, the magnetic flux generated by this coil is disturbed by the armature so that voltages are induced in the secondary winding.

v) The secondary windings are symmetrically placed, are identical & are connected in phase opposition so that emf induced in them are opposite to each other.

vi) The net output from the transformer is then the difference between the voltages of the two secondary windings.

vii) The position of the magnetic core determines the flux linkages with each winding.

viii) When the core is placed centrally, equal but opposite emfs are induced in the secondary windings and zero output is recorded. This is called as null position.

ix) If the core moves towards left of null position, the flux induced in 'S_1' is more than 'S_2' and hence

$$E_0 = E_{S_1} - E_{S_2}.$$

x) If the core moves toward the right of null position, the flux induced in 'S_2' is more than 'S_1' then.

$$E_0 = E_{S_2} - E_{S_1}$$

Advantages :-

i) The LVDT gives a high output.

ii) Less friction & noise because of absence of sliding contacts.

iii) Simple in design & fabrication.

Disadvantages :-

i) They are sensative to magnetic field.

ii) The dynamic responce is limited.

Applications :-

LVDT functioning as secondary transducer can act as a device to measure pressure, acceleration, vibration, force and liquid level.

Potentiometer:

Que; Explain potentiometer which is used for the displacement measurement.

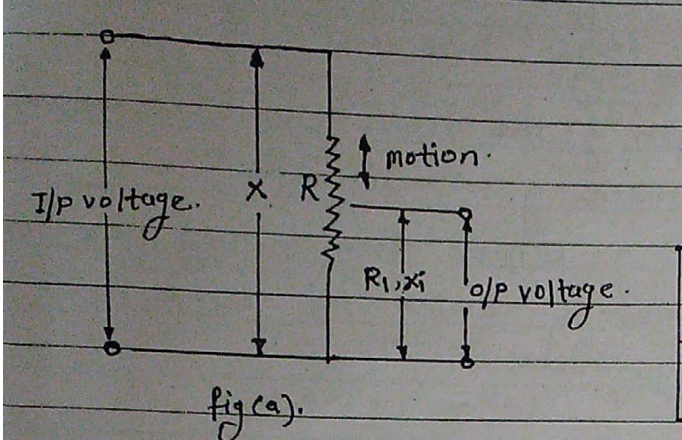


fig (a).

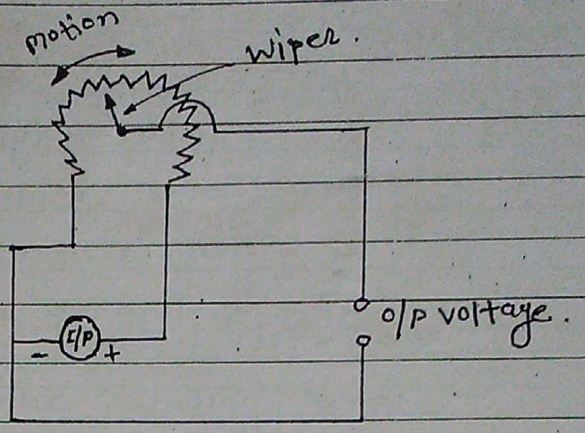


fig (b).

- Potentiometers are used to measure the displacement.
- It is a wire wound and used as a transducer.
- It converts the mechanical displacement to an electrical output.
- They may be used for linear or angular displacement.
- The electrical output voltage shown by the potentiometer is directly proportional to the displacement of the moving object.
- Linear displacement motion can be measured with the help of potentiometer set up in fig (a). and angular displacement motion can be measured by circular potentiometer set up in fig (b).

operation:→

1) - The displacement being measured is caused by the movement of the wiper.

2) - Because of this movement of wiper, the resistance changes, which changes the output voltage and this output voltage is directly proportional to the displacement.

Let, V_i - input voltage.

V_o - output voltage.

x - Total length of the translational potentiometer.

R - Total resistance of potentiometer.

x_i - displacement of wiper from initial position.

R_1 - resistance across which the output is measured.

∴ Output voltage =

$$= \left(\frac{\text{Resistance at o/p terminals}}{\text{Total resistance}}\right) \times \text{Input voltage}$$

$$\boxed{V_o = \frac{R_1}{R} \times V_i}$$

Resistance per unit length $= \frac{R}{x}$

∴ Resistance at o/p terminals.

$$R_1 = \frac{R}{x} \times x_i$$

∴ Output voltage $V_o = \dfrac{\frac{R \times x_i}{x}}{R} \times V_i$

$$= \frac{R \times x_i}{R \cdot x} \times V_i$$

$$V_o = \frac{x_i}{x} \times V_i$$

Now i/p voltage V_i & total length 'x' are constant.

thus

$$V_o \propto x_i$$

Advantages:

i) The device operates with appreciable constant sensitivity over a wide tempt. range.

ii) The wire used is strong and protected from surface corrosion by enamelling or oxidation.

Disadvantages:

i) The device has a limited life due to early wear of the sliding arm.

ii) The output tends to be noisy and erratic in high speed operation.

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* RVDT or Rotary variable Differential Transformer.

(Angular measurement).

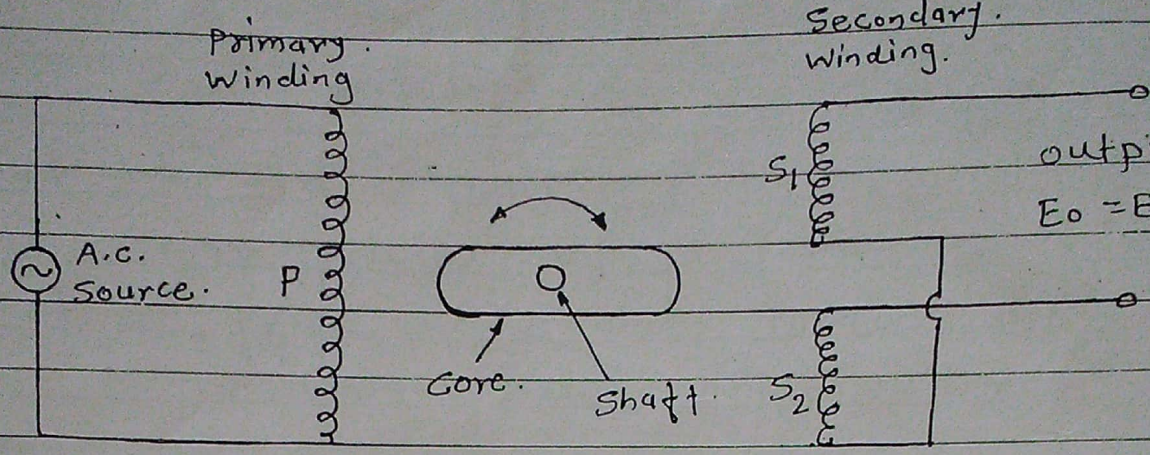

Fig: circuit connection of RVDT

i) RVDT means rotary variable differential transformer. RVDT is used for the measurement of angular displacement.

ii) The device consist of one primary and two secondary windings and the core is rotated between the windings by means of a shaft.

iii) The core is mounted on the rotating shaft whose angular displacement is to be measured.

iv) When a.c. current is supplied to the primary winding, the magnetic flux generated is disturbed by the armature so that voltages are induced in the secondary winding.

v) The secondary windings are symmetrically placed, are identical and are connected in phase opposition so that emf induced in them are opposite to each other.

vi) The net output from the transformer

ascertain - To find out

is then the difference between the voltages of the two secondary windings.

vii) At the null position of the core, the output voltage of secondary windings S_1 & S_2 are equal and in opposition. Therefore, the net output is zero.

viii) Any angular displacement from the null position will result in a differential voltage output.

ix) Clockwise rotation produces an increasing voltage of a secondary winding of one phase while counter-clock-wise rotation produces an increasing voltage of opposite phase.

x) Hence, the amount of angular displacement and it's direction may be ascertained from the magnitude and phase of the output voltage of the transducer.

* LDR or Light dependent resistor

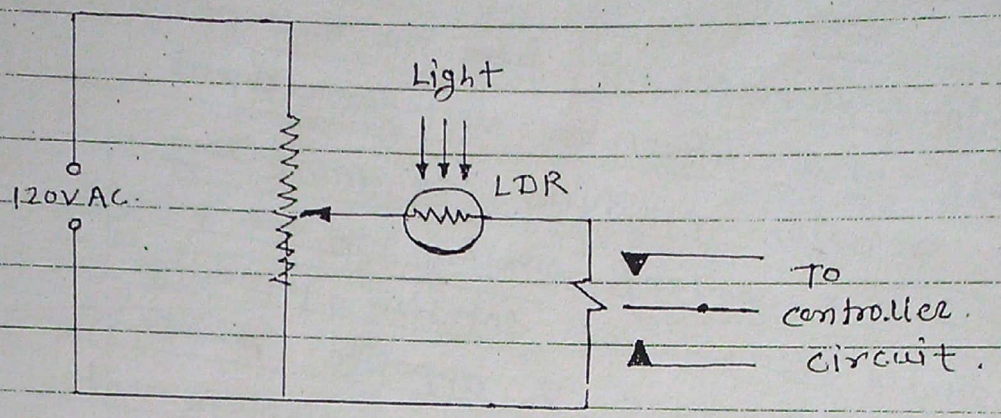

Fig: Light dependent resistor

i) A Light dependent resistor is shown in figure.

ii) It works on the principle of photo-conductive effect.

In photo-conductive effect, the electrical resistance of the material varies with the amount of incident light.

iii) When the LDR has the appropriate light shining on it, it's resistance is low and the current through the relay is consequently high enough to operate the relay.

iv) When the light is interrupted, the resistance increases causing the relay current to decrease enough to de-energise the relay.

Advantages:

i) Sensitivity is high
ii) Output given is in the form of electrical signal.
iii) Resolution is good.

Disadvantages: i) Non-linear characteristics.

—o—