Instrumental technique presentation

AMMETER

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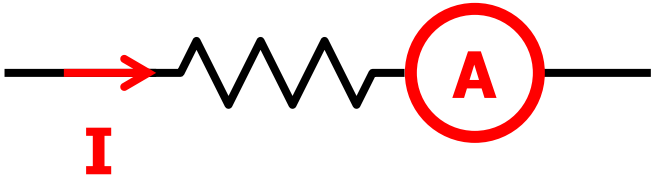
An **ammeter** is a measuring instrument used to measure the electric current in a circuit.

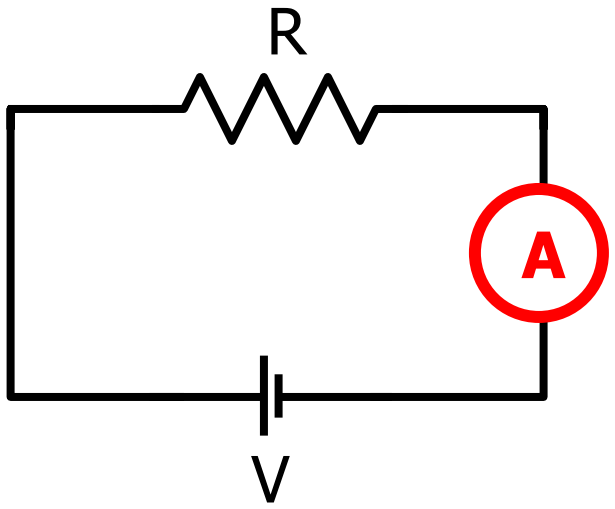


History

- The relation between electric current, magnetic fields and physical forces was first noted by Hans Christian orsted.
- In 1820, he observed a compass needle was deflected from pointing North when a current flowed in an adjacent wire.

The main principle of ammeter is that it must have a very low resistance and also inductive reactance. An ammeter is always connected in series.

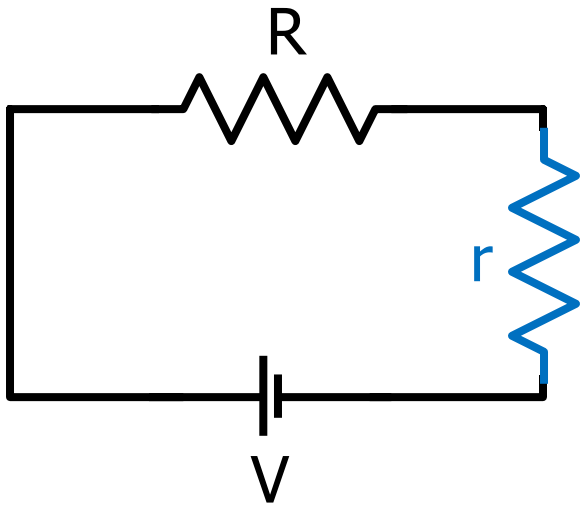
- It has very low impedance because it must have very low amount of voltage drop across. Power loss will be low due to low impedence.
- If it is connected in parallel it becomes almost a short circuited path and all the current will flow through ammeter as a result of high current the instrument may burn. So due to this reason it must be connected in series.
- An ideal ammeter must have zero impedance so that it has zero voltage drop across it so the power loss in the instrument is zero. But the ideal is not achievable practically.



Effect of ammeter on circuit

Measuring current in a simple circuit:

- connect ammeter in series



Are we measuring the correct current?
(the current in the circuit without ammeter)

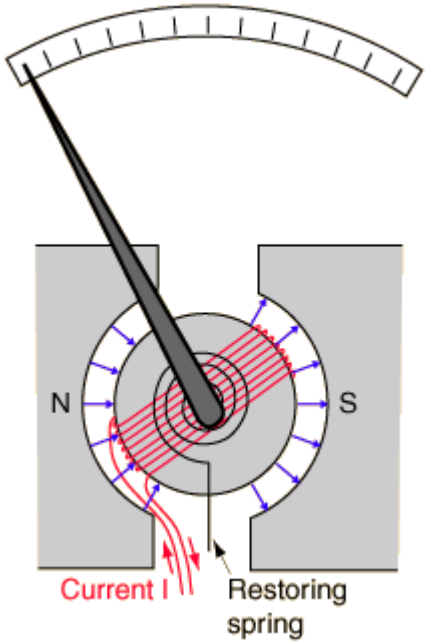
- any ammeter has **some resistance r.**
- current in presence of ammeter is $I = \frac{V}{R+r}$.
- current without the ammeter would be $I = \frac{V}{R}$.

To minimize error, ammeter resistance r must be very small.
(ideal ammeter would have zero resistance)

Designing an ammeter

Galvanometer:

- current flows through a coil in a magnetic field
- coil experiences a torque, connected needle deflects

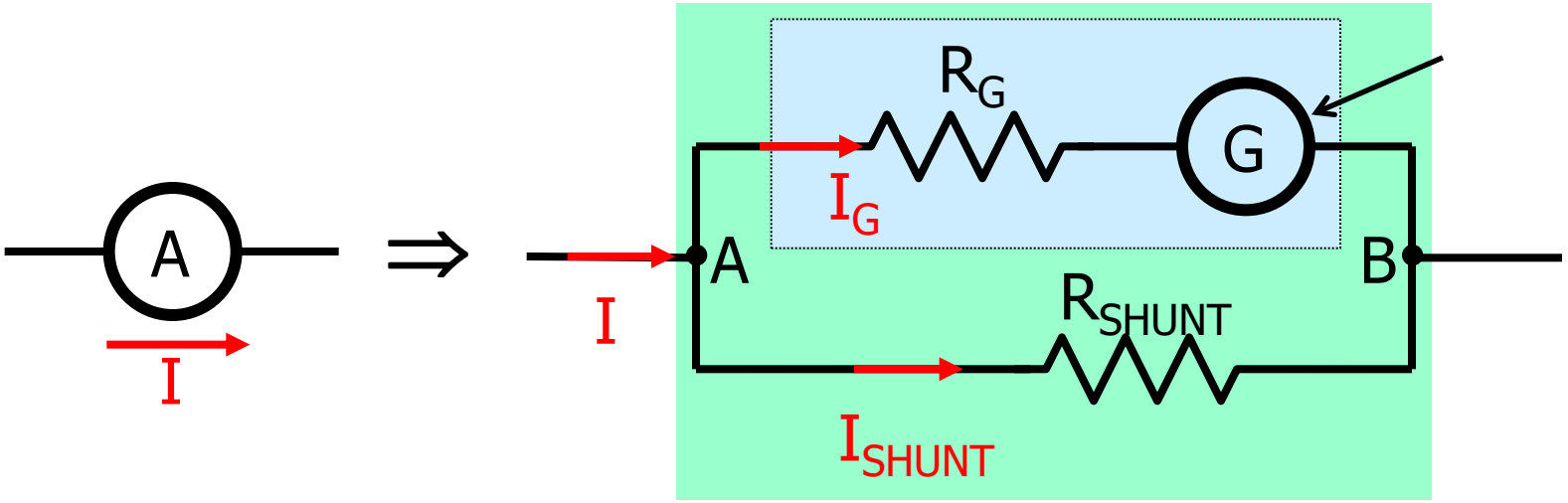


- Ammeter can be based on galvanometer.
- Simplest case: send current directly through galvanometer, observe deflection of needle
- Needle deflection is proportional to current. Each galvanometer has a certain maximum current corresponding to full needle deflection.

What if you need to measure a larger current?

Ammeter uses a galvanometer and a shunt, connected in parallel:

galvanometer



Everything inside the green box is the ammeter.

- Current I gets split into I_{shunt} and I_G

Classification or Types of Ammeter

Depending on the constructing principle, there are many types of ammeter

1.**Permanent Magnet Moving Coil(PMMC) ammeter**.
1.Moving Iron(MI) Ammeter.
2.Electrodynamometer type Ammeter.
3.Hot wire Ammeter.
4.Digital Ammeter.

Depending on this types of measurement we do, we have-
1.DC Ammeter.
2.AC Ammeter.
DC Ammeter are mainly PMMC instruments, MI can measure both AC and DC currents, also Electrodynamometer type thermal instrument can measure DC and AC.

MOVING-COIL AMMETERS

- When current carrying conductor placed in a magnetic field, a mechanical force acts on the conductor, if it is attached to a moving system, with the coil movement, the pointer moves over the scale.
- Suited for DC measurement because here deflection is proportional to the current and hence if current direction is reversed, deflection of the pointer will also be reversed so it is used only for DC measurement. This type of instrument is called D Arnsonval type instrument.

Deflecting torque, $T = BiNlbNm$

where

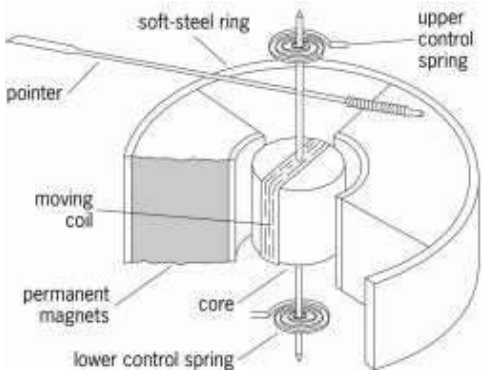
B = Flux density in Wb/m².

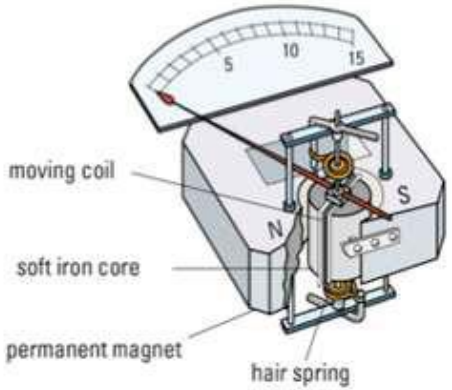
i = Current flowing through the coil in Amp.

l = Length of the coil in m.

b = Breadth of the coil in m.

N = No of turns in the coil.





Cutaway view of a moving-coil ammeter

MOVING-IRON AMMETERS

It is a moving iron instrument, used for both AC and DC, It can be used for both because the deflection θ is propotional square of the current so what ever is the direction of current, it shows directional deflection, further they are classified in two more ways-**Attraction type**.

Repulsion type.

Its torque equation is: $$T = \frac{1}{2} I^2 \frac{dL}{d\theta}$$

Where,

I is the total current flowing in the circuit in Amp.

L is the self inductance of the coil in Henry.

θ is the deflection in Radian.

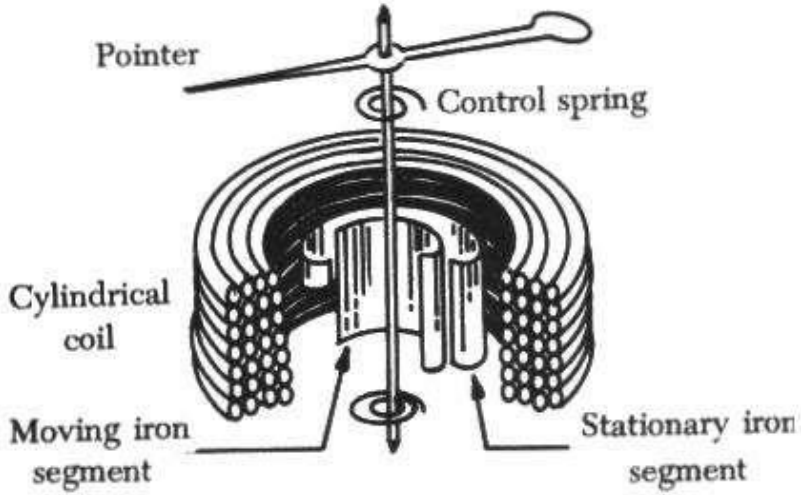
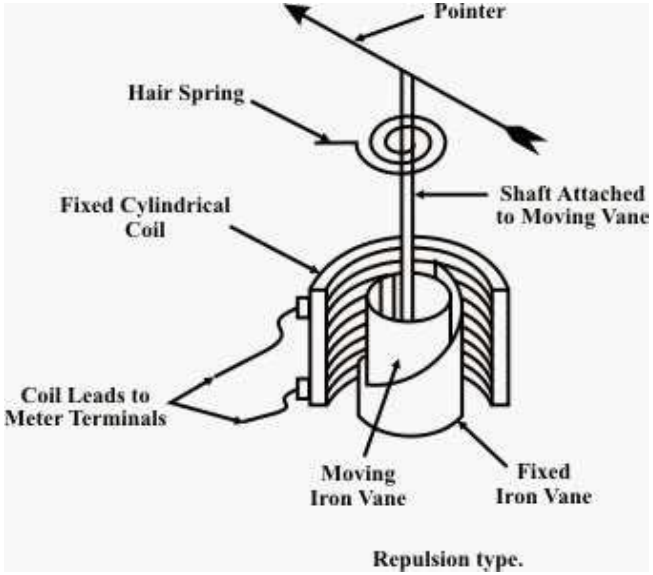


FIGURE 8–257. Moving iron-vane meter.



Repulsion type.

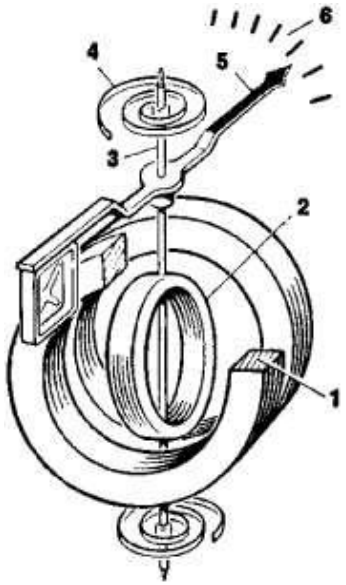
ELECTRODYNAMIC AMMETERS

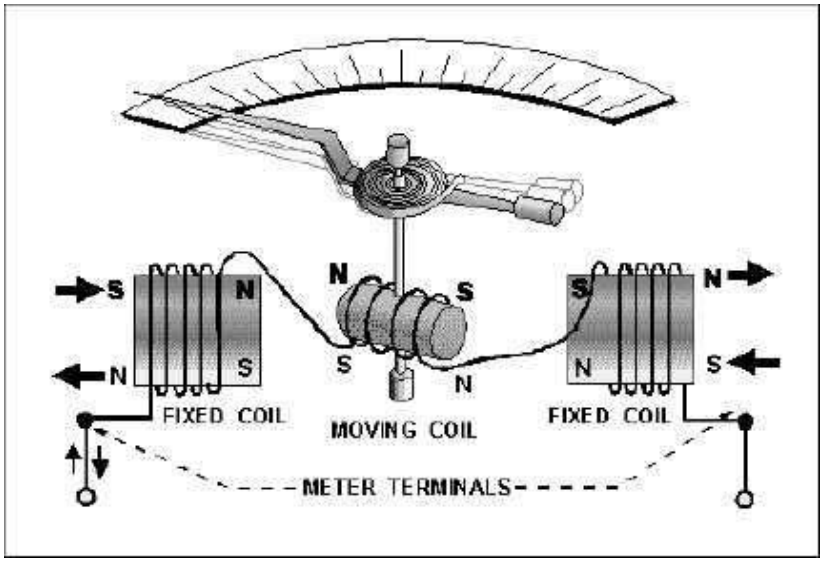
An electrodynamic movement uses an electromagnet instead of the permanent magnet of the d'Arsonval movement. This can be used to measure both i.e. AC and DC currents.

- There we have two coils, namely fixed and moving coils. If a current is passed through two coils it will stay in the zero position due to the development of equal and opposite torque. If somehow, the direction of one torque is reversed as the current in the coil reverses, an unidirectional
  torque is produced

$$T = I^2 \frac{dM}{d\theta}$$

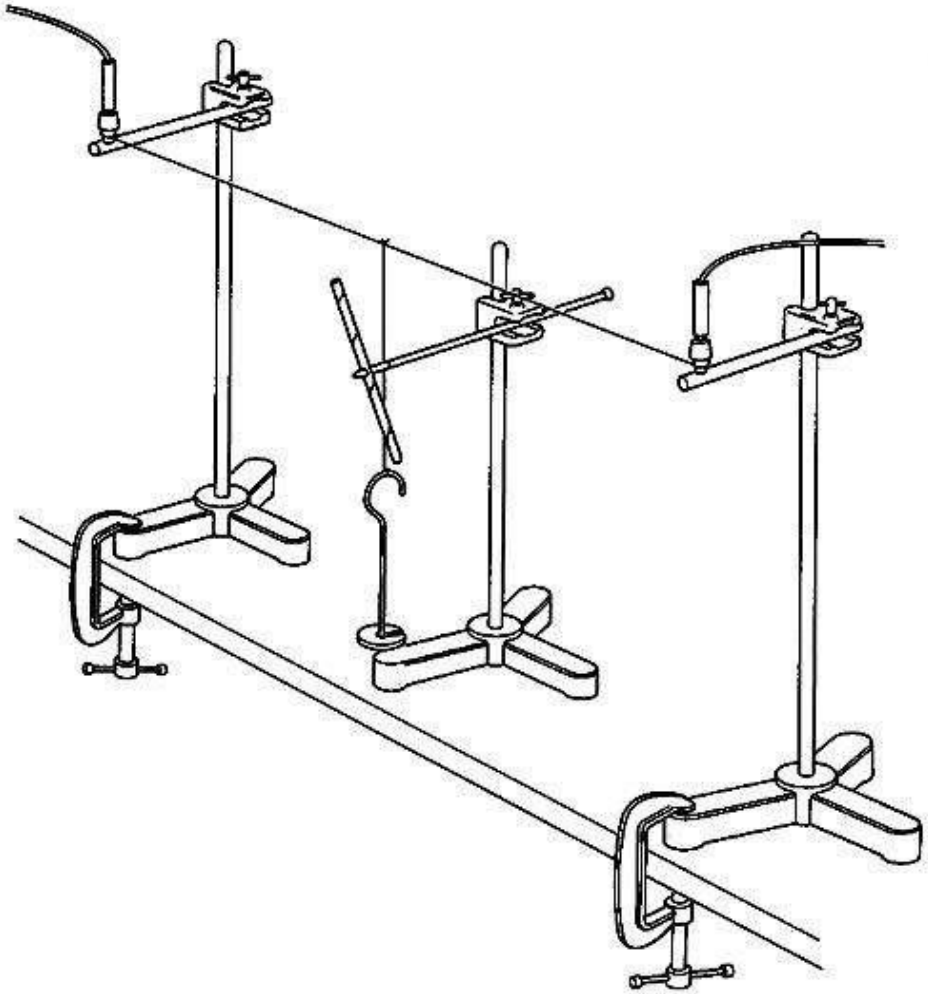
where,
I is the amount of current flowing in the circuit in Amp.
M = Mutual inductance of the coil.



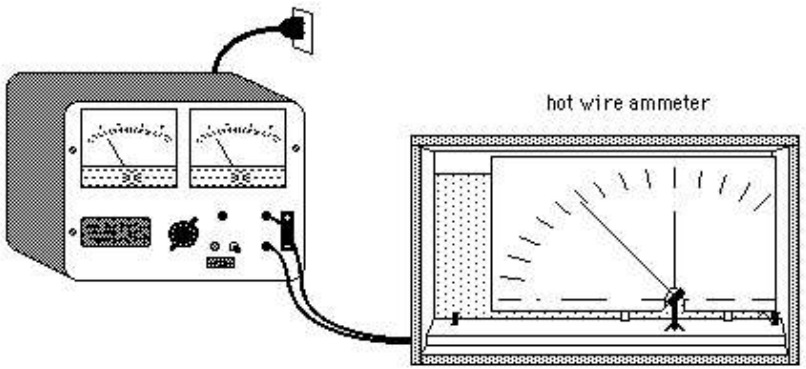


HOT-WIRE AMMETERS

In a **hot-wire ammeter**, a current passes through a wire which expands as it heats. Although these instruments have slow response time and low accuracy, they were sometimes used in measuring radio-frequency current.These also measure true RMS for an applied AC current.

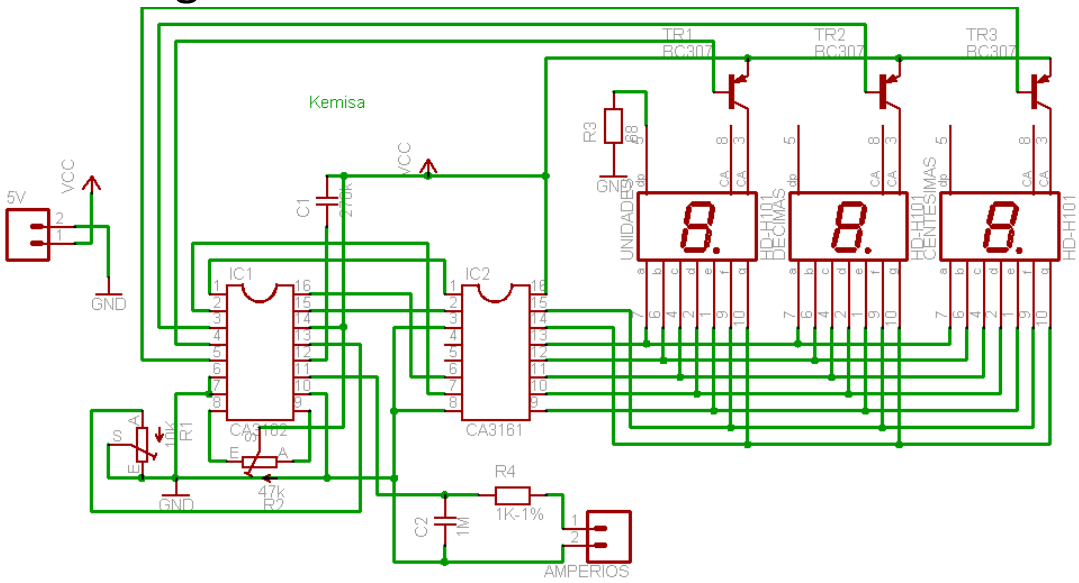


Theory: The heat being developed by the resistance expands the length of the wire which is being wrapped around the axis of the meter movement and, therefore, causes a change in deflection.



DIGITAL AMMETERS

Digital ammeter designs use a shunt resistor to produce a calibrated voltage proportional to the current flowing. This voltage is then measured by a digital voltmeter, through use of an analog to digital converter (ADC); the digital display is calibrated to display the current through the shunt.



PICO AMMETER

A picoammeter, or pico ammeter, measures very low electrical current, usually from the picoampere range at the lower end to the milliampere range at the upper end.Picoammeters are used for sensitive measurements where the current being measured is below the theoretical limits of sensitivity of other devices, such as Multimeters.

Thank You