Intermediate Elements

1. Amplifiers for amplifying small output signal
2. Compensating devices to improve characteristics like frequency response, impedance loading, etc.
3. Differentiating or integrating elements, so that output is proportional to desired input
4. Filters for filtering out unwanted portions of the signal.
5. A-D/D-A converters, for converting analog type signals to digital form or vice versa.
6. Data transmission elements, which transmit the transducer output to a certain distance as desired

Amplifiers

Types

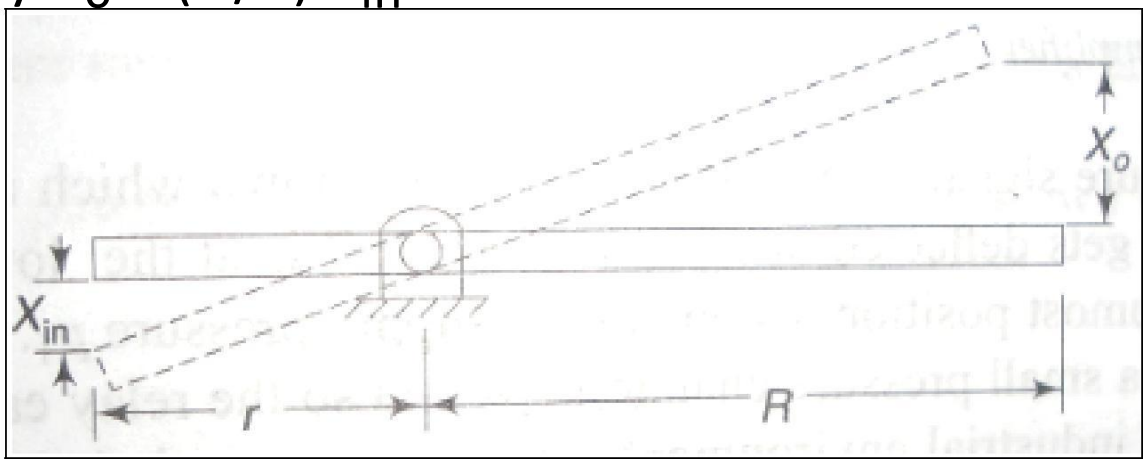
1. Mechanical
2. Hydraulic
3. Pneumatic
4. Optical
5. Electrical / electronic

Attenuators are the devices which reduce the signal in magnitude.

Mechanical Amplifying Element

- Simple in operation, rugged type and inexpensive.
- Eg. Huggenburger extensometer employs mechanical amplification using a system of compound levers.
- Dial gauge uses system of gears, while Bourdon pressure gauge uses a combination of gears & levers.
- Disadvantage of friction and stiction effects, backlash errors and inertia effects due to relatively higher mass, temp. effects.
- For angular motion, using gears with gear ratio N/n, output signal is given by $\theta_0 = (N/n)\ \theta_{in}$

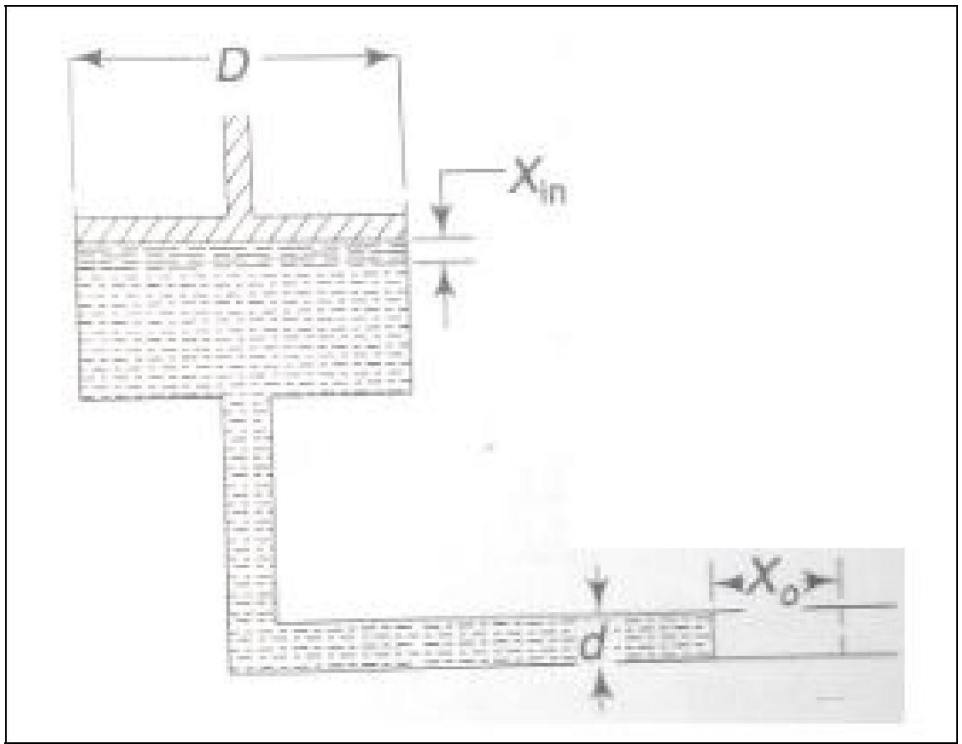
$$X_o = \left(\frac{R}{r}\right) X_{\text{in}}$$



Hydraulic Amplifying Element

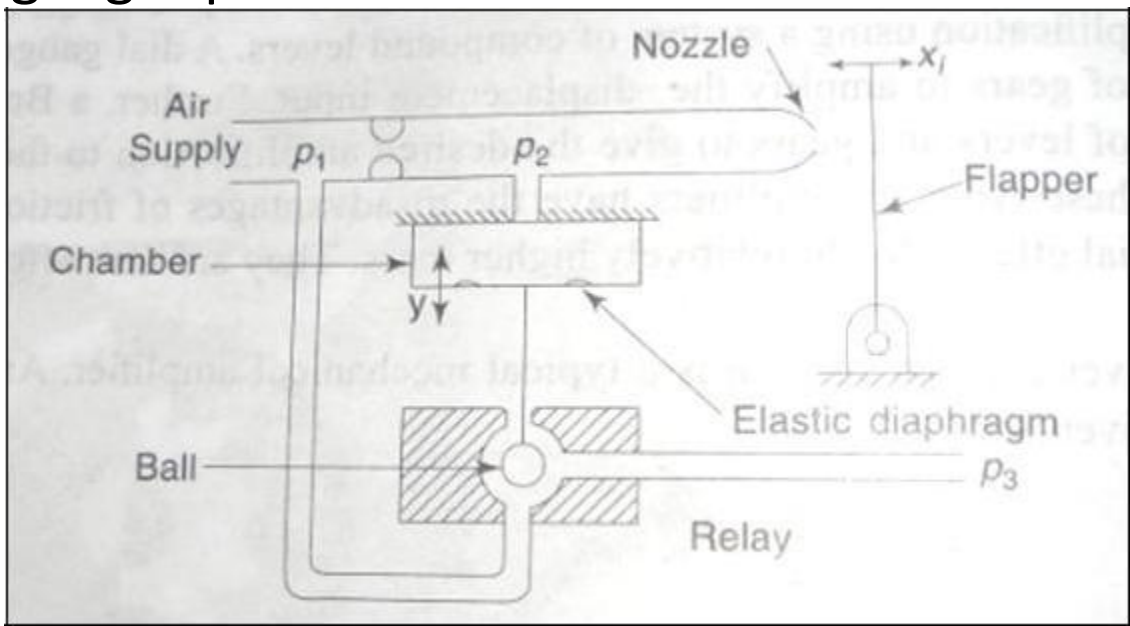
- Applied in the form of hydraulic actuators in the control elements used in the automobile hydraulic brakes and hydraulic steering systems.
- Advantage of compactness.
- Disadvantage of Leakage and problems in dusty environments.

$$X_o = \left(\frac{D}{d}\right)^2 X_{in}$$



Pneumatic Amplifying Element

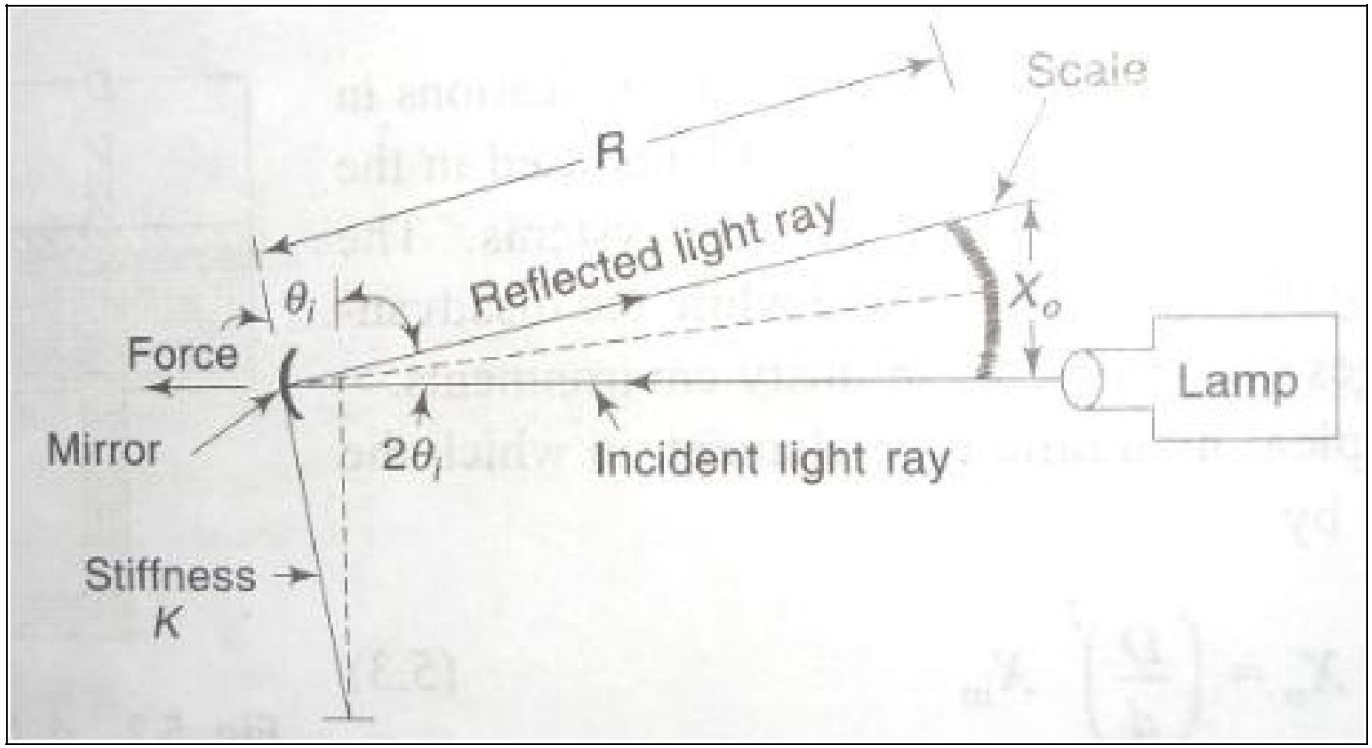
- For amplifying pressure signal P_2, a ball type relay is operated by motion of an elastic diaphragm which gets deflected due to P_2.
- If ball is at the lowest position, pressure P_3 is atmospheric pressure.
- If ball is at the topmost position, pressure P_3 equals air supply pressure P_1.
- Thus P_3 changes from gauge pressure to P_1 due to small pressure change in P_2.



Optical Amplifying Element

- Lamp and scale type of amplifier is inexpensive and provide large amount of amplification.
- Can not be employed in dynamic type of measurement due to inertia effect of mirror mass.

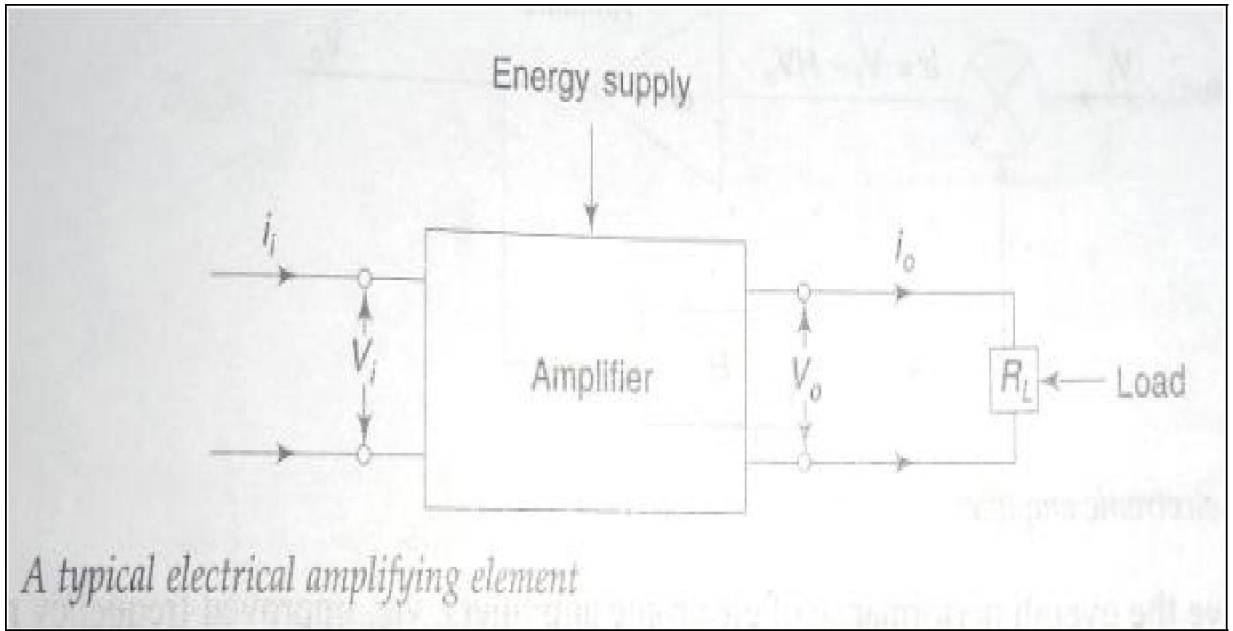
$$X_o = 2R\theta_i$$



Electrical Amplifying Element

Ideal electrical amplifiers should have following characteristics:

1. Infinite input impedance (no loading effect0
2. Zero output impedance
3. A very large gain to improve resolution
4. Zero output for zero input
5. Ability to filter spurious inputs
6. Excellent frequency response



A typical electrical amplifying element

1. ac and dc amplifiers,
2. carrier amplifiers, and
3. chopper amplifiers.

The voltage input of transducer V_i is amplified to V_o. Thus, gain G of amplifier is

$$G = \frac{V_o}{V_i}$$

$$\text{Current amplification} = \frac{i_o}{i_i}$$

and

$$\text{power gain} = \frac{V_o}{V}\frac{i_o}{i_i}$$

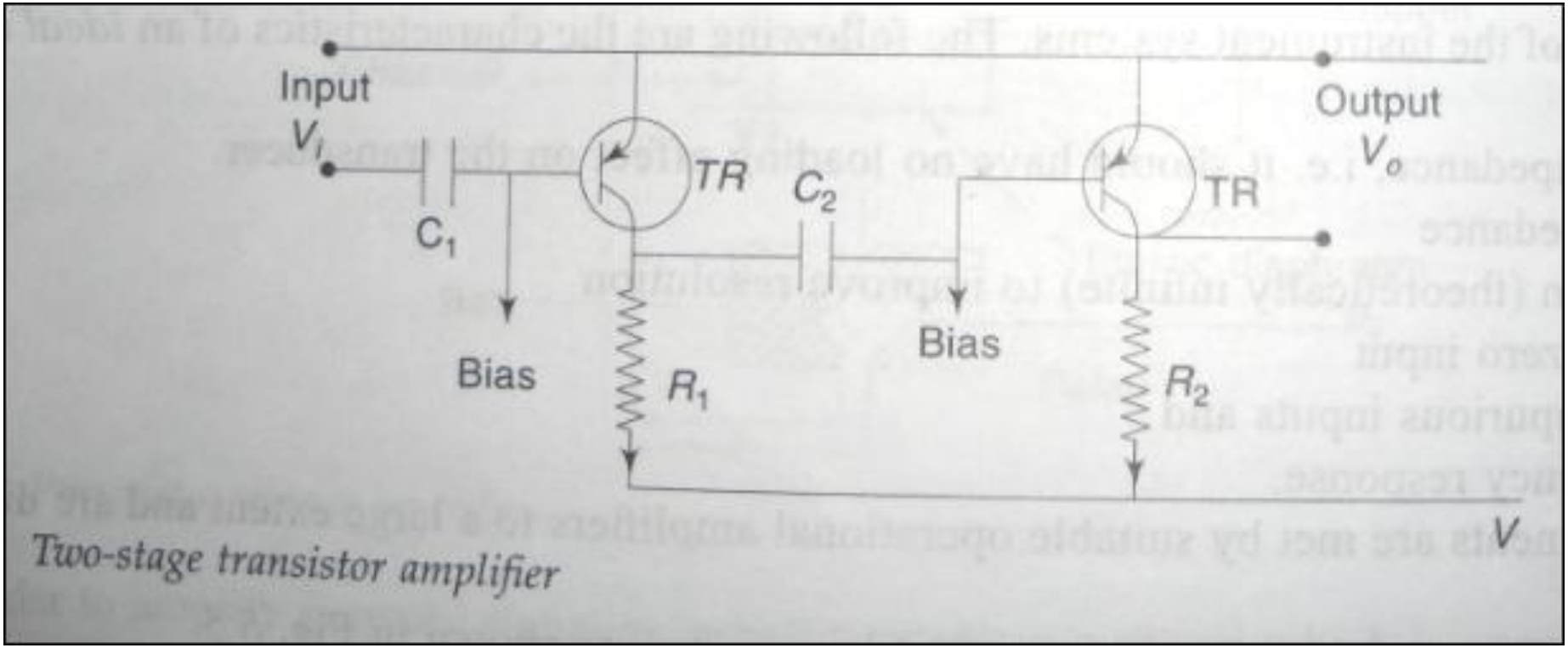
It is usual to express the gain in decibels (dB), for convenience, with

$$\text{power gain (dB)} = 10 \log \frac{p_2}{p_1}$$

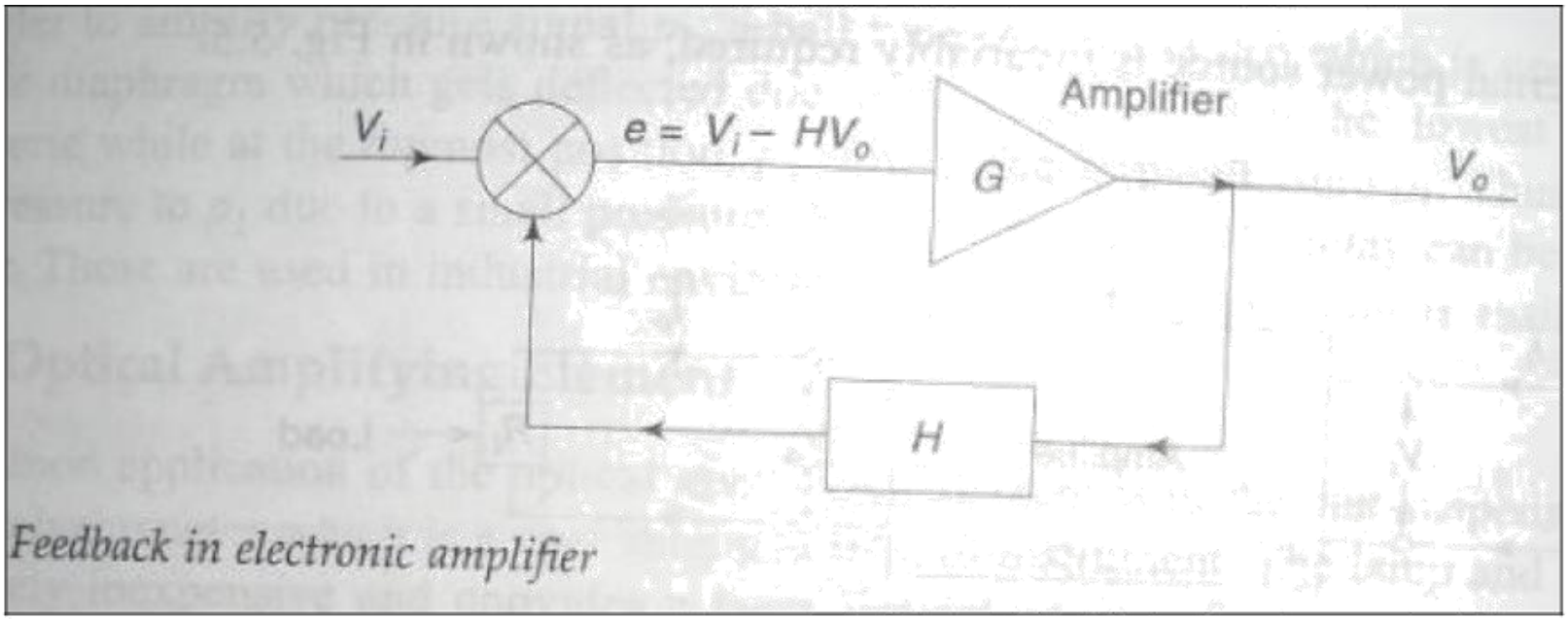
Since power is proportional to the square of voltages,

$$\text{Voltage gain (dB)} = 20 \log \frac{V_o}{V_i}$$

AC & DC Amplifiers



Two-stage transistor amplifier



Feedback in electronic amplifier

If the amplifier gain is G and a feedback device with gain H is employed such that input e to the amplifier is $(V_i - HV_o)$ then output

$$V_o = G(V_i - HV_o) \tag{5.7}$$

or
$$\frac{V_o}{V_i} = \frac{G}{1+GH} \tag{5.8}$$

If $GH >> 1$,

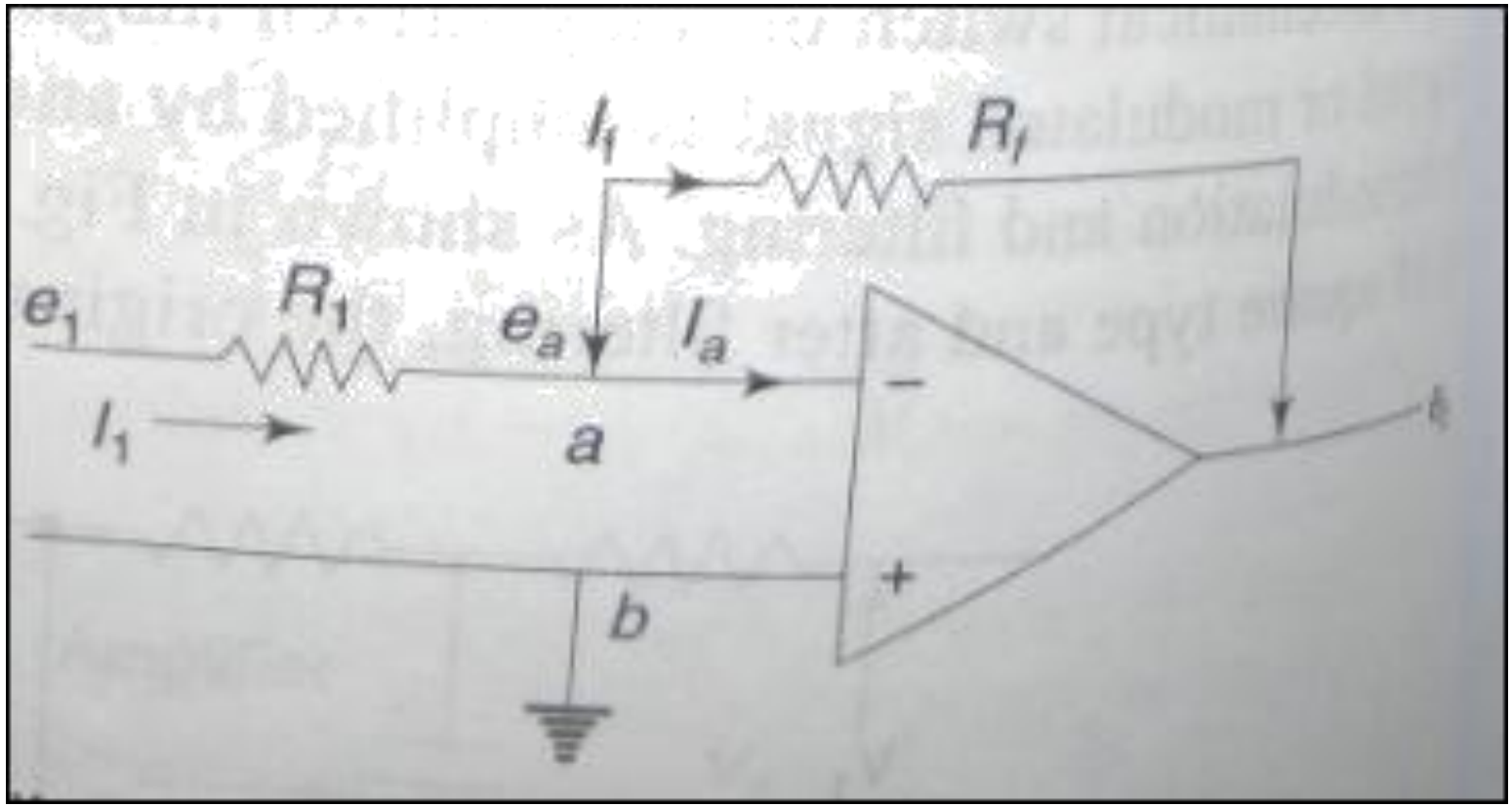
Overall gain $\frac{V_o}{V_i} = \frac{1}{H}$

Operational Amplifiers

- Important signal conditioning element.

- Should poses following characteristics:

1. High gain dc difference amplifier type, having two input terminals and act on a difference in voltages at terminals.
2. Available as an integrated circuit
3. High input impedance
4. Low output impedance
5. Normally used along with outside resistance and capacitances.


I_f
R_f
e_1
R_1
e_a
I_a
I_1
a
b
−
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