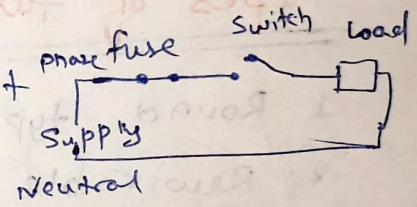
Electrical Installations

* Unit - 6 *

Switch Gear :- Used for electrical circuit switching, protection and controlling against overloads & short circuits.

- **Classification** - basis of voltage level -
  (1) Low voltage (LV) - up to 1KV
  (2) Medium voltage (MV) - 3kv to 33kV
  (3) High voltage (HV) - Above 33kV

* **Low voltage (LV) switchgears** -
Switches, fuses, circuit breakers, off load electrical isolators etc. (Relay)
→ connected in series with circuit



** **Fuse**
→ When an excessive current flows through the fuse then according to I^2Rt, heat is produced & fuse wire will melt so that circuit becomes open.

→ **material for fuse wire**
- Low melting point
- High conductivity
- Low cost
- Low ohmic loss

Ex Zinc, Copper, tin etc

→ **Advantage**
- No need of maintenance
- breaks circuit without any noise or smoke
- cheapest form.

→ **Disadvantage**
It has to be replaced after each operation.

Switches — A device which is used for opening or closing of electrical circuit.

Fuse — Short piece of wire which melt when excess current flow through it.

Circuit breaker :- To operate manually under normal condition & Automatically under fault condition.

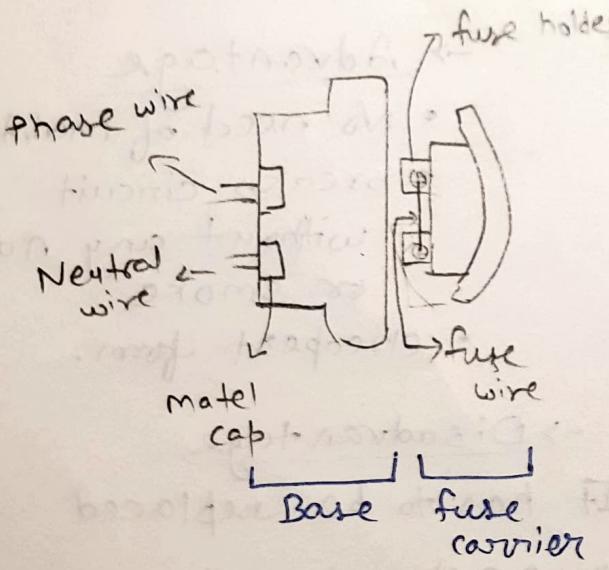
Relay :- To detect the fault & give the require info to the breakers for circuit in *

- Types of fuses

1 Round type fuse unit
2. Rewirable (kit-kat) type fuse
3. Cartridge Type fuse

**

(1) Kit-kat type

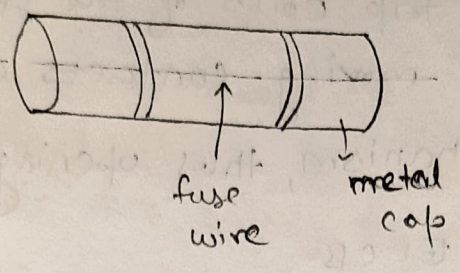


Advantage
-> Easy to remove & replace
-> fuse of negligible cost

Disadvantage
-> Lack of discrimination
-> Small time lag
-> No current limiting feature.

Rating upto 100 A

(2.) Cartridge type fuse -



→ Totally enclosed type fuse

→ Cartridge filled with powder or granular material.
(filler) (Sand, $CaCO_3$, quartz)

Current rating upto 800A

Advantage

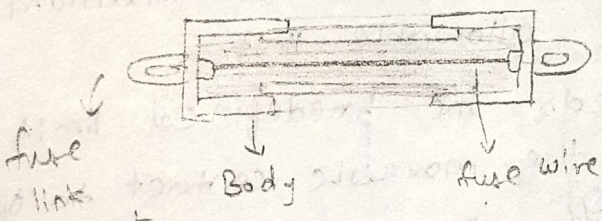
→ Non spoilable fuse element for long time period due to insulation

→ Usually more accurate.

Disadvantage

→ More expensive to replace

(3) H.R.C. (High Rupturing Capacity) fuse -



→ Body of ceramic cylinder.

→ Used at industry level.

Advantage

→ Capable of clearing high as well as low fault current

→ High speed of operations.

Disadvantage

→ They have to be replaced after each operation.

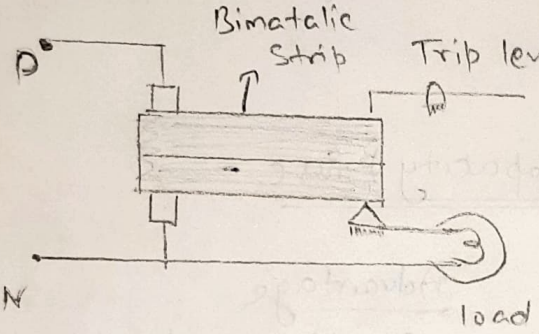
CB — when a fault occurs in any part of the system, the trip coils of the breaker get energized & the moving contacts are pulled apart by some mechanism, thus opening the ckt.

- MCB
- MCCB
- ELCB

• MCB :- (Miniature Circuit Breaker)

Automatic operated switch under overload & in short circuit condition.

→



It is a switch which automatically turns off when the current flowing through it passes the maximum allowable limit.

When the current exceeds the predefined limit, a solenoid forces the movable contact to open. And the MCB turns off. [Latch mechanism]

Advantage

(1) MCB's are replacing the re-wireable switch i.e., fuse units for low power domestic & industrial application.

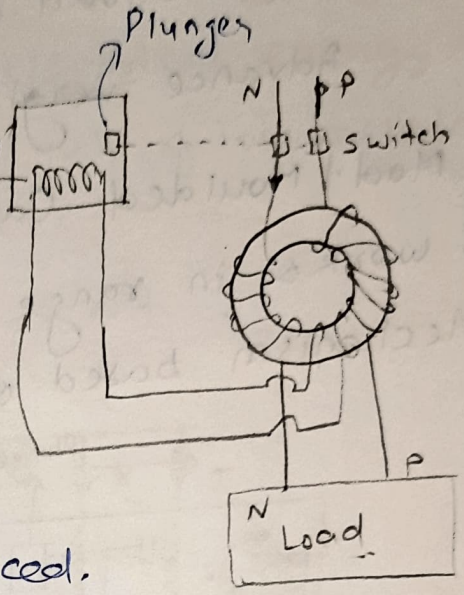
(2) MCB is combination of all three functions in a wiring system like → switching
→ Overload & short circuit protection.

Overload current → by bimetallic strip
Short circuit → Using solenoid

• ELCB

Earth leakage circuit Breaker.

→ used with electrical machine to avoid the electrical shock & provide the safety to human or animal.



CELCB

→ In Normal condition

$B_{net} = 0$

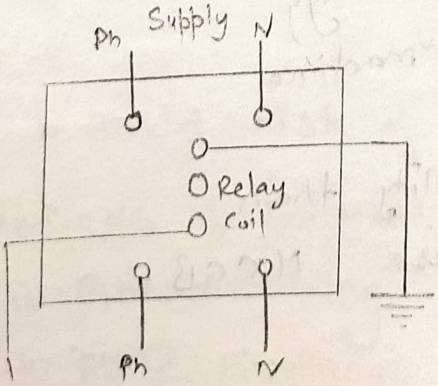
So no current induced.

→ In faulty condition due Earth leakage

$B_{net} \neq 0$

So current will induce → tripping relay plunger will be pulled due to induced magnetic field. & break the circuit.

* CELCB ⇒ current earth leakage circuit Breaker
* ✓ELCB ⇒ Voltage earth leakage circuit Breaker.



Sense the sufficient voltage and exceed voltage will be grounded.

Connect to metal body part.

VELCB

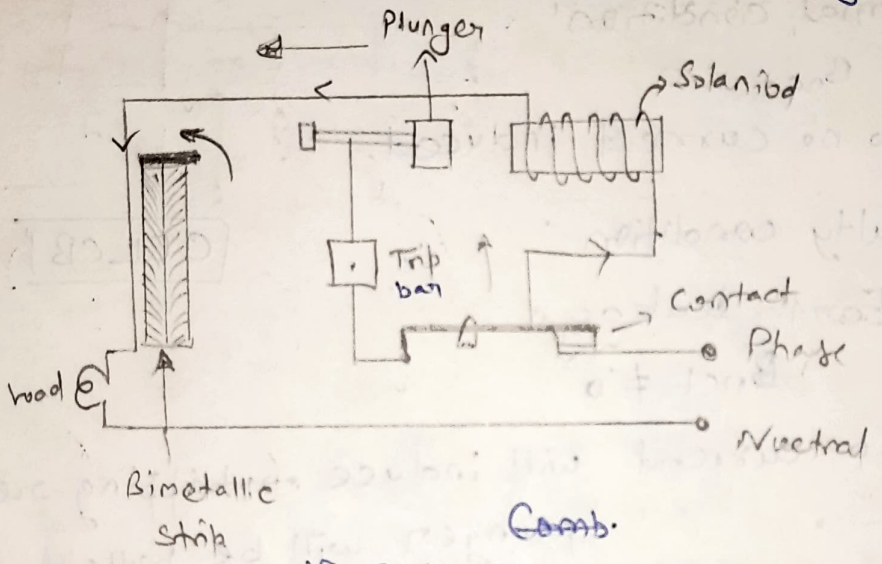
• MCCB Used to protect the circuit from overload & ifrom short circuit condition

Advance ~~vers~~ version of MCB

Mod. [Moulded Case Circuit Breaker]

→ works in range of 63A to 3000 A.

* Mechanism based on 1. thermal - magnetic circuit



~~Comb.~~

if Strip take extra time to bend then Solanoid will take charge & strike the Trip bar. and open the circuit.

Advantage

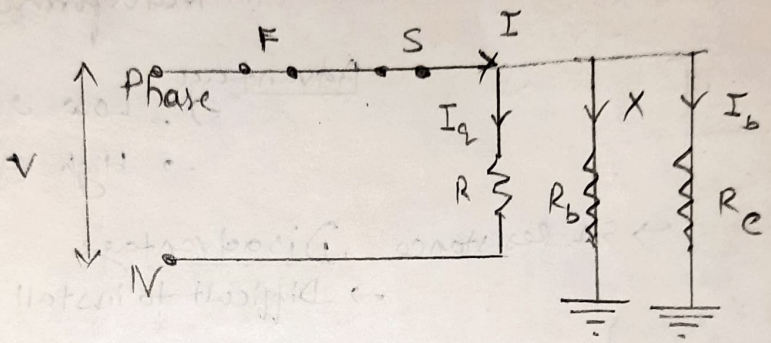
Economical & tested technology
Advance high power machine

Disadvantage

Provide less flexibility than electronic release MCCB.

* **Earthing** :- The process of transfering immediate discharge of electrical energy directly to the earth with the help of low resistance wire.

* Potential of earth = 0 Volt



The earth resistance is affected by -

(a) Material properties of earth, wire & electrode.

(b) Temperature & moisture content of soil.

(c) Depth of pit.

(d) Quantity of charcoal.

- **Necessity of Earthing** :-

(i) To protect the operating personnel from shock.

(ii) To maintain line voltage constant under unbalanced condition.

(iii) To avoid risk of fire due to earth leakage current.

- **Methods of Earthing** :-

(i) Pipe Earthing

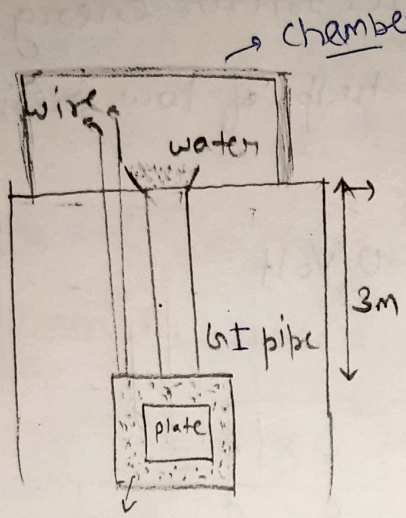
(ii) Plate Earthing

(iii) Rod earthing

(iv) Strip or wire earthing

(1) Plate Earthing

Plate → Galvanized Iron
or
Copper plate



→ 5Ω Resistance

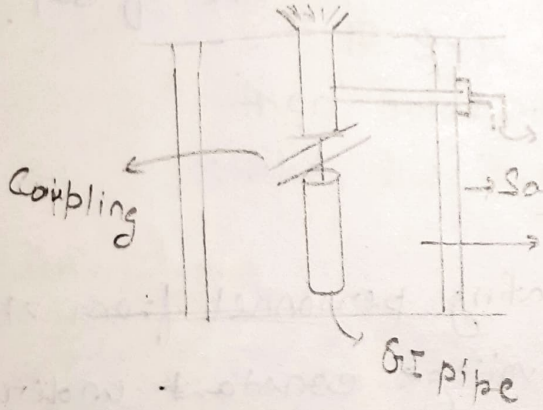
Application
(i) Generator
(ii) Transformer

Advantage
→ Low resistance
→ High Efficiency.

Disadvantage
→ Difficult to install

(2) Pipe Earthing

diameter of 38 mm
length = 2m

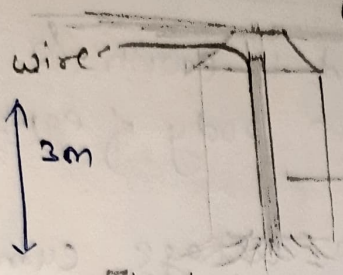


Application
(i) Residential & Comercial

Advantage
(i) Simple design
(ii) Easy to install

Disadvantage
(i) High impedance
(ii) Hard to install in rocky Salt.

(3) Rod Earthing



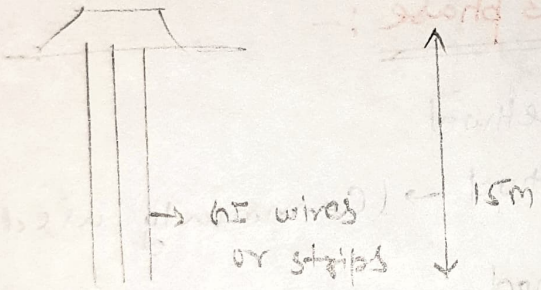
→ Earth Rod ⇒ G.I. Rod of

Electrolytic salts → used to reduce Earth resistance.

Application

→ Areas where soil is loose or sandy.

(4) Strip or wire Earthing



Application

In Rocky area.

Earth resistence → Should be kept as low as possible

It depends on

→ Moisture, Condition or temperature of Soil.

→ Depth of electrode, size, material of electrod.

→ Quantity & Quality of Soil + Charcoal.

• Difference between Earth wire & Neutral wire

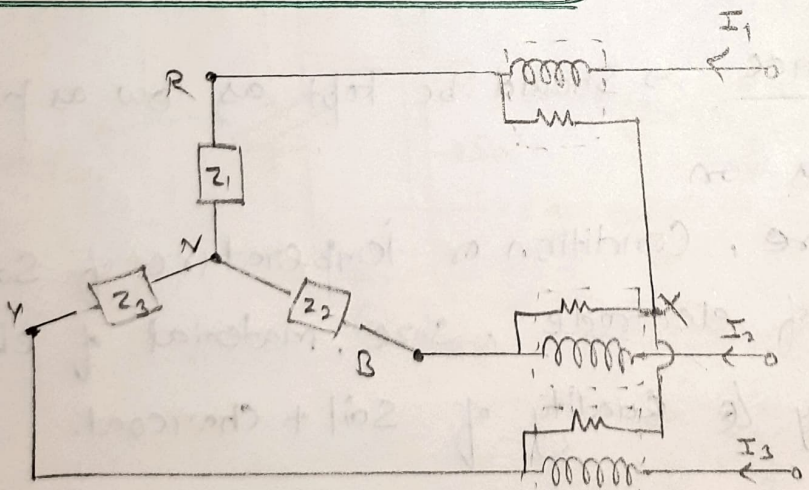
Neutral wire	Earth wire
(i) In 3p-4w system 4th one is neutral.	· Connected to earth & metallic body of equipment
(ii) Return path of 3-phase current when unbalanced condition.	transfer leakage current from metalic body to the earth.
(iii) In single phase, act as return path of line current	

• Power measurement in 3 phase :-

(i) Three wattmeter method

(ii) Two wattmeter method → (Commonly used)

(1) Three wattmeter method



$P_{total} = W_1 + W_2 + W_3$

Y or Star Connection

for Delta Connection

X will neutral point.

Prove

Avg power by W_1

$$W_1 = \frac{1}{T}\int_0^T V_{Rn} i_1 \, dt$$

Similarly for W_2 & W_3

$$W_2 = \frac{1}{T}\int_0^T V_{Yn} i_2 \, dt \qquad W_3 = \frac{1}{T}\int_0^T V_{Bn} i_3 \, dt$$

Total power

$$P = W_1 + W_2 + W_3$$

$$P = \frac{1}{T}\left[\int_0^T (V_{Rn} i_1 + V_{Yn} i_2 + V_{Bn} i_3)\right] dt$$

$\because V_{Rn} = V_{RN} + V_{Nn}$

& $I_1 + I_2 + I_3 = 0$

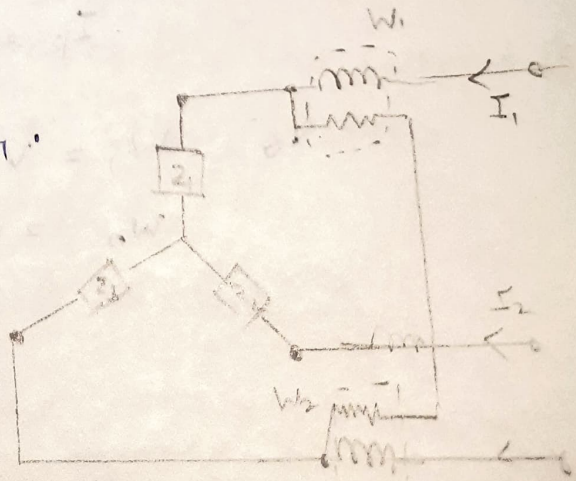
So $$P = \frac{1}{T}\int_0^T (i_1 V_{RN} + V_{Nn} i_1 + V_{YN} i_2 + V_{Nn} i_2 + V_{BN} i_3 + V_{Nn} i_3)\, dt$$

$$P = \frac{1}{T}\int_0^T (V_{RN} i_1 + V_{YN} i_2 + V_{BN} i_3)\, dt = \text{Total Power}$$

(2) Two-Wattmeter Method

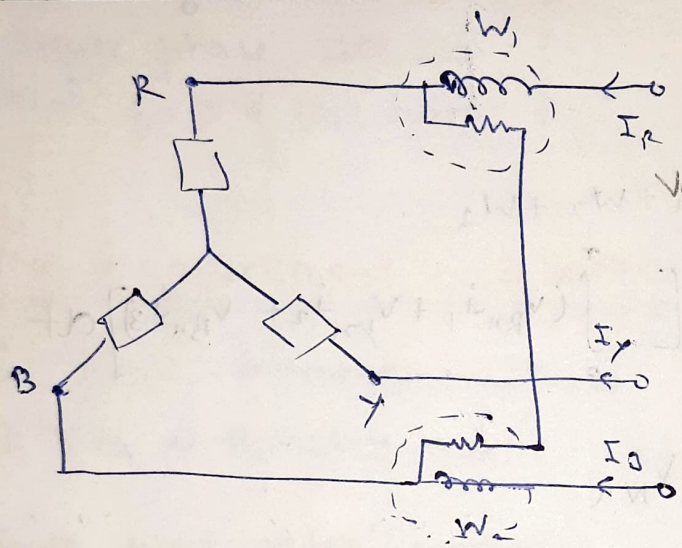
Here, only two wattmeter will be connected.

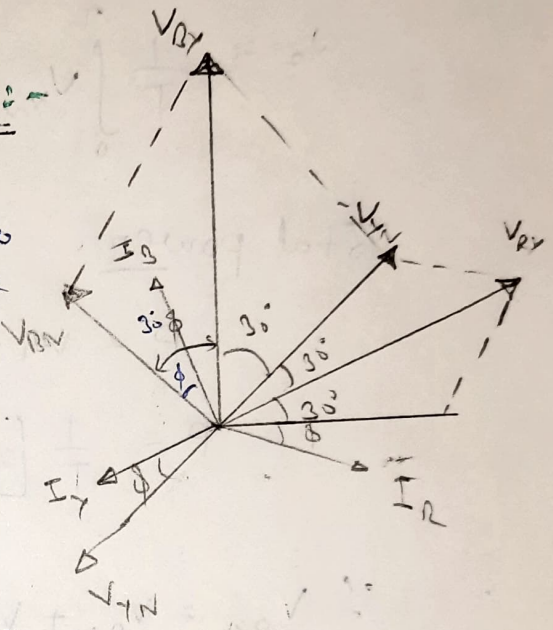
$W_1 + W_2$ = Total power



It is useful to total power regardless of
(i) load unbalance
(ii) Source unbalance
(iii) Difference in wattmeter
(iv) Wave-form of Source
(v) Phase sequence

Calculation of Power factor:-





$V_{RN} - V_{YN} = V_{RY}$

$W_1 = V_{RY} I_R \cos(30° + \phi)$

$W_2 = V_{BY} I_B \cos(30° - \phi)$

$\because V_{RY} = V_{BY} \Rightarrow$ line voltage $= V_L$

$I_R = I_B \Rightarrow$ line current $= I_L$

So $W_1 = V_L I_L \cos(30° + \phi)$

$W_2 = V_L I_L \cos(30° - \phi)$

$$P_{Total} = W_1 + W_2$$

$$P_T = V_L I_L [\cos(30^\circ + \phi) - \cos(30^\circ - \phi)]$$

$$P_T = V_L I_L (2 \cos 30^\circ \cos\phi)$$

$$\boxed{P_T = \sqrt{3} V_L I_L \cos\phi}$$

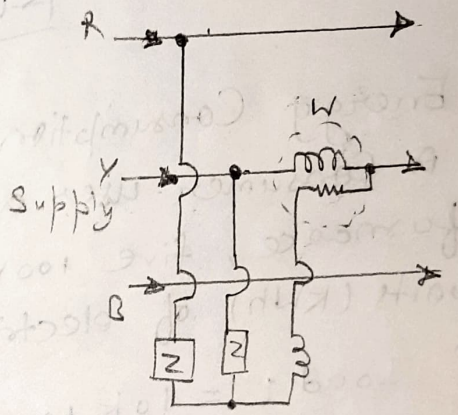
$$\& \quad W_2 - W_1 = V_L I_L \sin\phi$$

** Power factor $\Rightarrow$ $\phi = \tan^{-1}\left(\sqrt{3}\,\frac{(W_2 - W_1)}{(W_2 + W_1)}\right)$

$$\boxed{\text{Reactive Power} = \sqrt{3}(W_2 - W_1)}$$

Note: If the 3 phase load is balanced, then one wattmeter method is sufficient to measure power.

$$\boxed{P_T = 3 \times W}$$



Example: The power input to a 2000 V, 50 Hz, 3 phase motor running on full load at an efficiency of 90% is measured by two wattmeters which indicate 300 kW & 100 kW respectively. Find (i) the input (ii) the power factor (iii) the line current & output?

Soln: $W_2 = 300$ kW, $W_1 = 100$ kW

(i) Input $= W_1 + W_2 = 400$ kW

(ii) Power factor

$$\tan\phi = \sqrt{3}\left(\frac{W_2 - W_1}{W_2 + W_1}\right)$$

$$\phi = \tan^{-1}(\sqrt{3}/2) = 40.9^\circ$$

$$\boxed{\phi = 40.9^\circ}$$

power factor = Cosϕ.

= Cos(40.9°)

= 0.756 Ans

(iii) Output = input x 90% = input x 0.9

= 400 x 0.9 = 360 kW

Line current I_L = ?

$W_T = \sqrt{3} V_L I_L \cos\phi$

$I_L = \frac{W_T}{\sqrt{3} V_L \cos\phi}$

$I_L = \frac{400 \times 10^3}{\sqrt{3} \times 2000 \times 0.756}$

$\boxed{I_L = 152.74 A}$ Answer

Q. Energy Consumption – 1 unit = 1 kWh

A Consumer uses a 10kw geezar, a 6kW electrical furnance, five 100w bulbs for 15 Hours. How many units (kWh) of electrical energy have been used?

Soln Load 1 = 10kW geezar

Load 2 = 6 kW electrical furnance

Load 3 = 500 watt (5x100 watt bulbs) = 0.5kW

Total Load = 16.5kW

Total time taken = 15 hrs

Energy Consumed = 15 x 16.5 (Power x time)

= 247.5kWh

Then total energy Consumption (in units)

= 247.5 unit