

## **Department of Electrical and Electronics Engineering**

### **Computer Aided Electrical Drawing**

#### **Module-1**

##### **Winding Diagrams:**

- (a) Developed Winding Diagrams of D.C. Machines: Simplex Double Layer Lap and Wave Windings.
- (b) Developed Winding Diagrams of A.C. Machines:
- (c) Integral and Fractional Slot Double Layer Three Phase Lap and Wave Windings.
- (d) Single Layer Windings – Un-Bifurcated 2 and 3 Tier Windings, Mush Windings, Bifurcated 3 Tier Windings. Single line diagrams of generating stations and substations.

#### Module-2:

**Single Line Diagrams:** Single Line Diagrams of Generating Stations and Substations Covering Incoming Circuits, Outgoing Circuits, Busbar Arrangements (Single, Sectionalised Single, Main and Transfer, Double Bus Double Breaker, Sectionalised Double Bus, One and a Half Circuit Breaker Arrangement, Ring Main), Power Transformers, Circuit Breakers, Isolators, Earthing Switches, Instrument Transformers, Surge or Lightning Arresters, Communication Devices (Power-Line Carrier) and Line Trap

#### Module-3:

##### **Electrical Machine Assembly Drawings Using Design Data, Sketches or Both:**

Transformers - Sectional Views Of Single And Three Phase Core And Shell Type Transformers .

#### Module-4:

##### **Electrical Machine Assembly Drawings Using Design Data, Sketches or Both:**

D.C. Machine - Sectional Views of Yoke with Poles, Armature and Commutator dealt separately.

#### Module-5:

##### **Electrical Machine Assembly Drawings Using Design Data, Sketches or Both:**

Alternator – Sectional Views of Stator and Rotor dealt separately

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### Module-3

### TRANSFORMERS

**Objective:** To draw the sectional views of single and three phase core and shell type transformers.

#### PROBLEM 1:

Draw to half scale the sectional plan of 1 limb showing the winding on a core of an oil immersed 12000/550V, 3phase transformer. The core is 24cm in dia & has 3 steps. The internal & external diameters of low tension windings are 25.4cm & 29.8cm respectively, & of high tension 2.3cm thick & outer dia 40.5cm. show the arrangements for keeping the coils in position & the oil ducts.

**Given:**

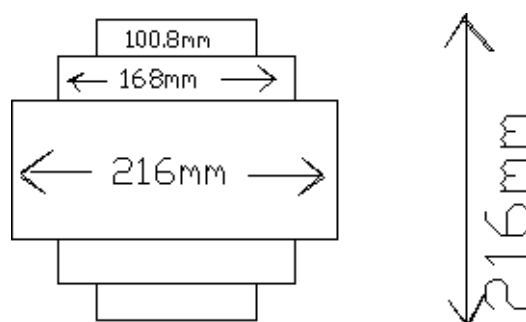
3 stepped core

Width of larger stamping = 216mm

Width of the intermediate stamping = 168mm

Width of smaller stamping = 100.8mm

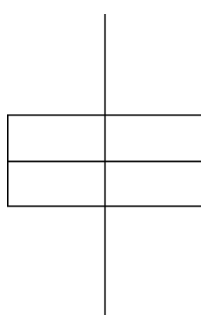
**To draw sectional plan:**



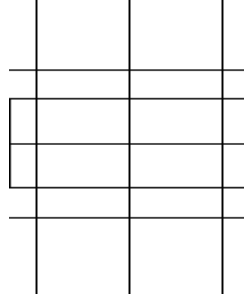
#### Step1: To draw 3 stepped core

1. Set limits
2. Type line, keeping polar status bar in ON mode
3. Draw a line @216<0, by obtaining midpoint draw a vertical reference line as shown
4. Offset horizontal line on both side by 50.4mm & join it as shown in fig (a)
5. Offset horizontal line again by 84mm on both sides
6. Next Offset vertical line on both side by 84 mm as in fig (b)
7. Trim the unwanted lines as shown in fig (c)

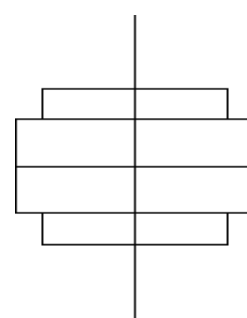
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(a)



(b)

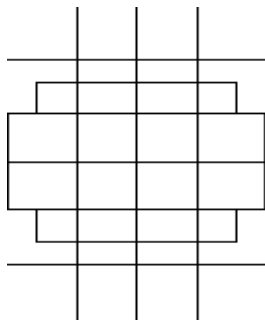


(c)

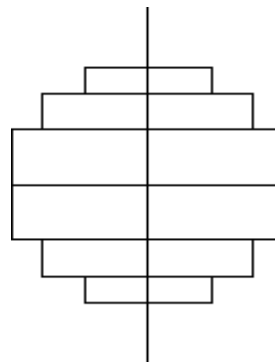
8. Offset horizontal line on both side by 108mm

9. Offset vertical line on both side by 50.4mm on both sides as shown in fig (d)

10. Trim the unwanted lines ,so that 3 stepped core appears as in fig (e)



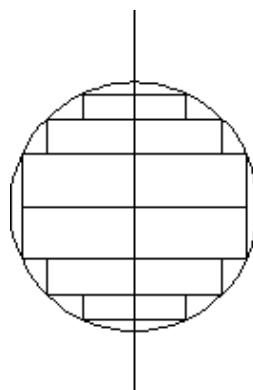
(d)



(e)

### **Step 2: To draw inner & outer dia for LV & HV winding**

- Type 'circle' in the command prompt
- Specify the centre point
- Specify the radius of the circle or diameter: Type 'D' & press enter
- Specify dia of circle : 240mm



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- Repeat the above 4 steps to draw inner & outer dia of LV & HV wndg with following details

Inner dia of LV= 254mm

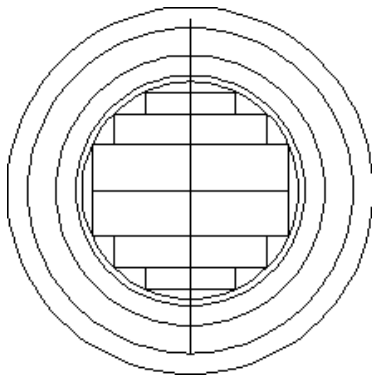
Outer dia of LV= 298mm

Inner dia of HV =  $405-2(23)=359\text{mm}$

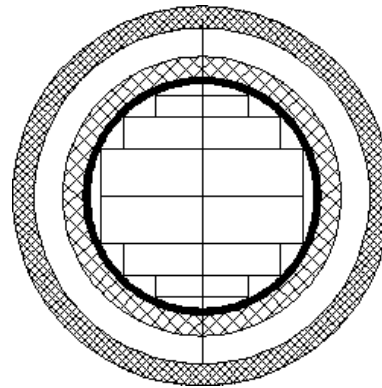
Outside dia of HV =405mm

### **Step3: Hatching**

Select hatch icon, select the pattern of hatch, then hatch LV & HV wndg as shown below



Before hatching LV & HV



Before hatching LV & HV

### **Step 4: To draw insulating ring:**

- The space available for insulating ring between the region of LV & HV is calculated as:
- Inner dia of HV – outer dia of LV= $359-298=61\text{mm}$        $\{61\text{mm}/3 = 20.3\}$
- Hence inner dia of insulating ring =  $298+20.3=318.3\text{mm}$
- Outer dia of insulating ring =  $359+20.3=338.7\text{mm}$
- Hatch the region of insulating ring
- Draw a rectangle as shown below & hatch it in fig(1)
- Use array command (polar array) , to array the rectangles as shown below in fig(2)specify total no. of items as 12 & angle to fill as 360 & also select the centre point & click OK & next place d bolts using line & arc command as shown

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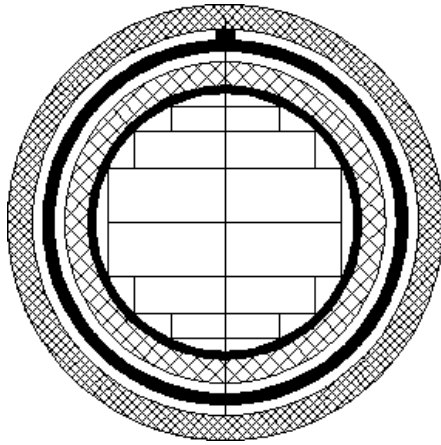


Fig 1

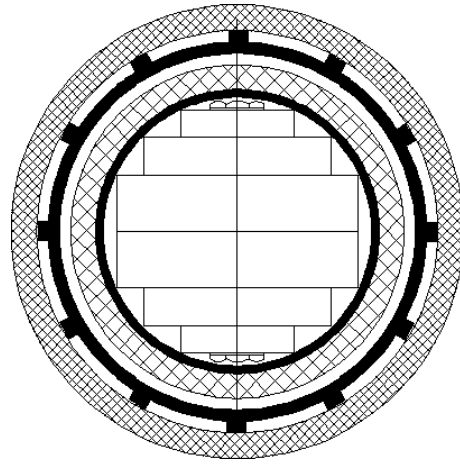


Fig 2

### **PROBLEM 2:**

Make a proportional longitudinal cross section of a 3phase,oil cooled power transformer showing the HT & LT windings, diameter of circumscribing iron core =22.6cm,dia of secondary winding in 2 concentric layers, inside 25cms,outside 28.1cms,height of secondary winding 41.2cm,dia of primary winding, inside 32cm,outside 36.8cm.total height of primary winding , including 10 spacers, 40 cms.

**Given:** Dia of circumscribing circle = $d=22.6\text{ cm}=226\text{ mm}$

Width of larger stamping  $W_d=0.9d=(0.9*22.6)=20.34\text{ cm}=203.4\text{ mm}$

**Step 1 :** Set limits

**Step2 :** Draw the line **ab** of length 203.4mm using line command as shown

a  b

**Step 3:** To find total height :

Total height = ht.of sec wndg + Insulatn at top +Insulation at bottom

= 41.2 cm + (wooden packing + metal ring + moulded Bakelite) + (wooden packing + metal ring)

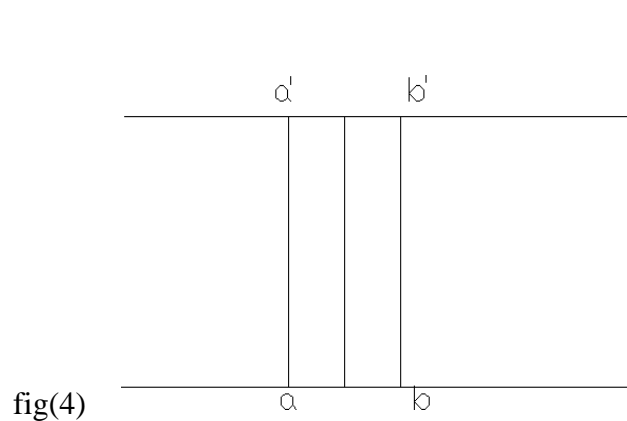
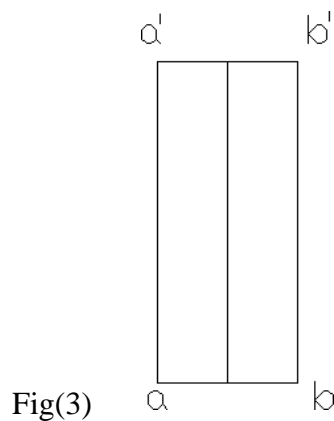
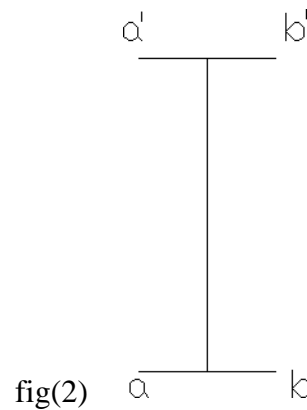
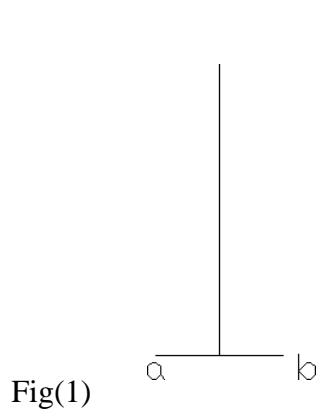
= 412mm + ( 1+1+1.8.....cms) + (1+1.....cms)

= 412mm + 38mm + 20mm

= 470 mm

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- Next obtain the midpoint of line **ab**, from that midpoint draw a vertical line using line command of height of 470mm as shown in fig(1)
- Offset the line **ab** above at a distance of 470mm to obtain line **a'b'** as in fig(2)  
Join the lines **aa'** & **bb'** as in fig(3)  
Extend the line **ab** on either of the sides  
Extend the line **a'b'** on either of the sides as shown below in fig (4)



### Step 4 : To include primary & secondary windings

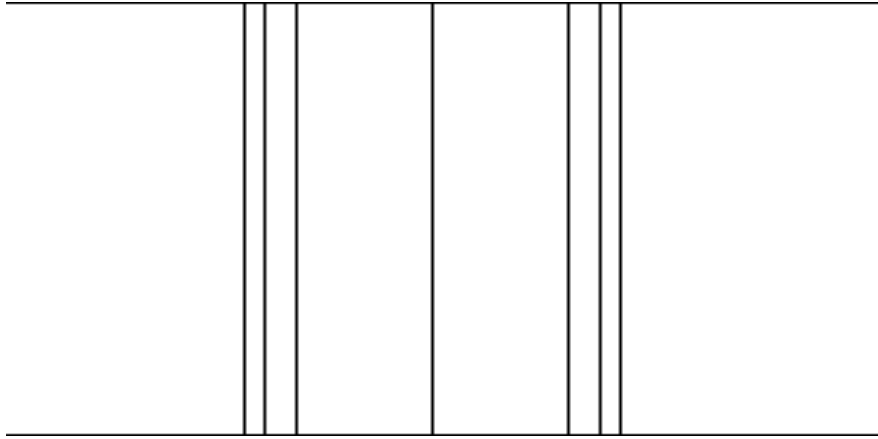
**Secondary wndg :** Inner dia = 25cm = 250mm

Outer dia = 28.1cm = 281mm

Again offset centre reference line on both the sides to draw Inner dia ,therefore offset distance is  $250\text{mm}/2 = 125\text{mm}$

Similarly offset centre reference line to draw outer dia, hence offset distance is  $281\text{mm}/2 = 140.5\text{mm}$ ... ..as shown below

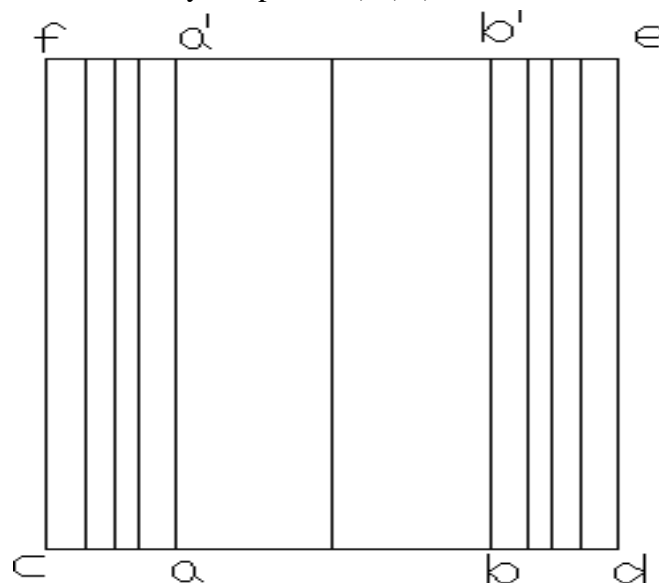
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**Primary winding :** Inner dia = 32cm = 320 mm

Outer dia = 36.8cm = 368 mm

Similarly offset the reference line to draw inner & outer dia of pri with offset distance of  $320\text{mm}/2 = 160\text{mm}$  &  $368\text{mm}/2 = 184\text{mm}$  respectively & trim the extended lines which are beyond points **c, d, e, f** as shown below.



**Step 5 :** To include insulations at top & bottom for pri & sec wndgs

**To include wooden packing & metal ring**

Select line **ac**

Offset the line **ac** horizontally at a distance of 10mm above, again offset the line obtained at a distance of 10mm above

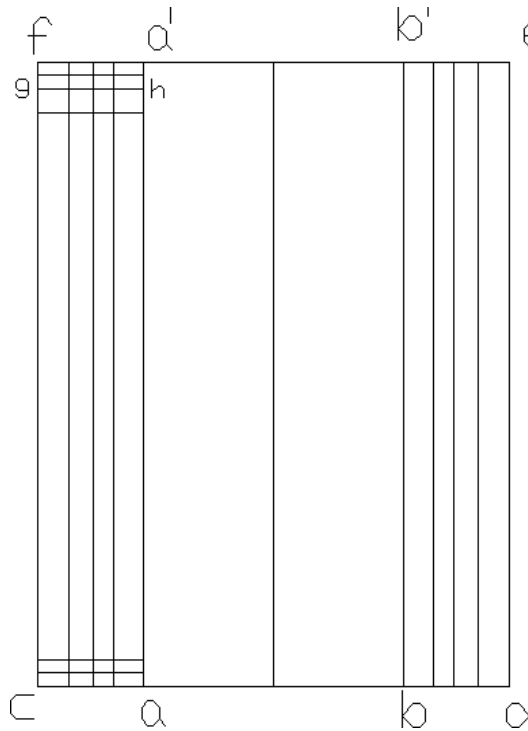
Similarly offset the upper part .

**To include moulded Bakelite insulation at top:**

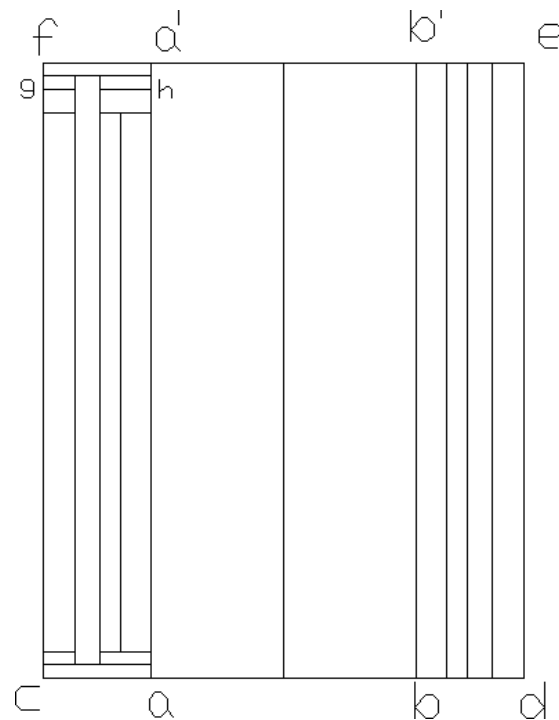
Offset the line **gh** horizontally at a distance of 18mm at the top as in fig(1) & trim the Unwanted lines by selecting proper cutting edges as in fig(2)

& hatch the corresponding 3 different kinds of insulation with different types of hatch Pattern as shown below in fig (3)

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Fig(1)



Fig(2)

### **Step6: To draw concentric type of winding for sec wndg**

Height of sec wndg =  $41.2\text{cm} = 412\text{mm}$

Obtain the midpoint of line **AB**, draw a vertical line from the midpoint.

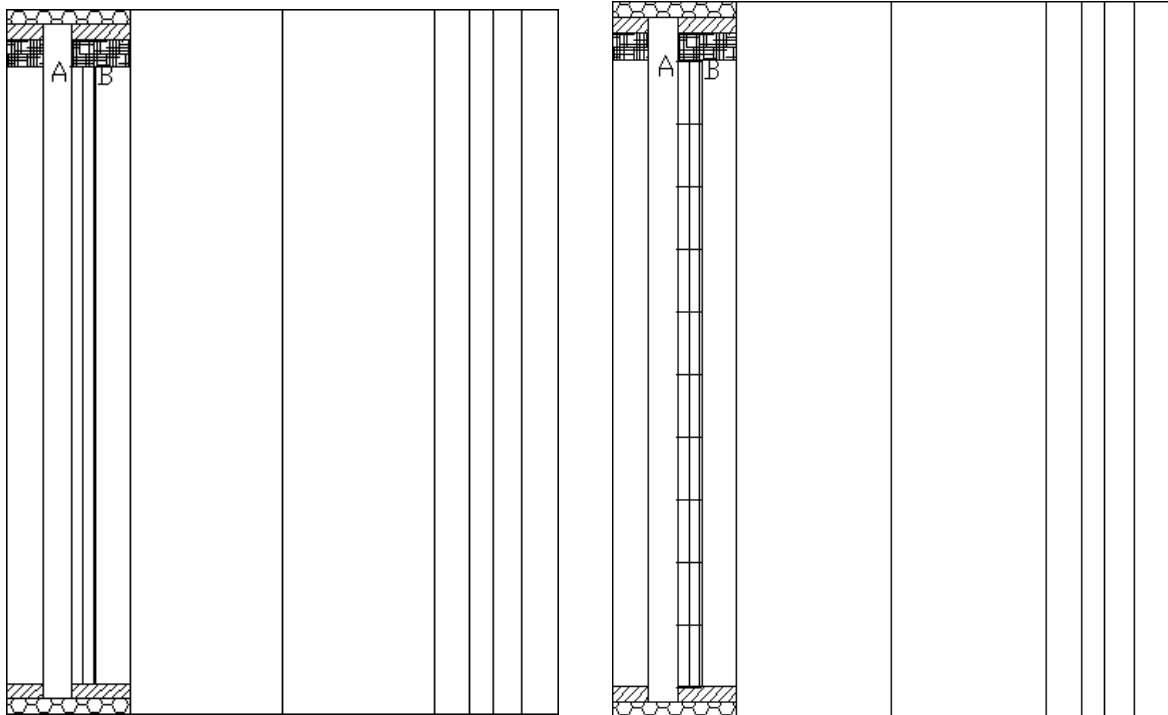
As shown in fig (3)

**To include** : 10 concentric wndg :  $412\text{mm}/10 = 41.2\text{mm}$

Select line AB, then offset it at a distance of 41.2mm, next select line CD offset it at a

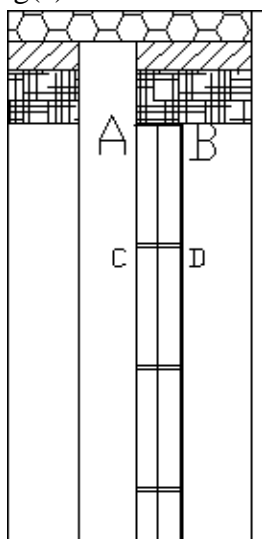
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distance of 1mm or 1.5 mm above it. repeat the same for entire height of sec wndg  
Hatch it as shown

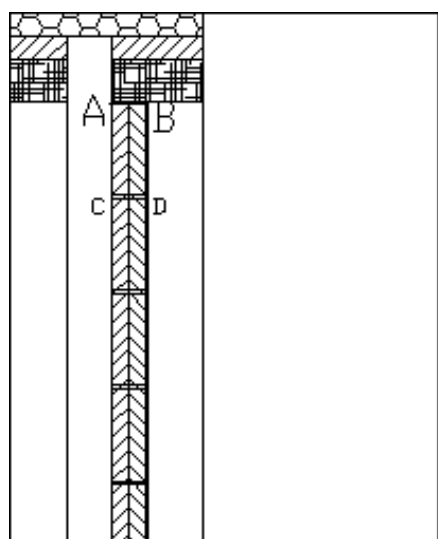


**To include :** 10 concentric wndg :  $412\text{mm}/10 = 41.2\text{mm}$

Select line AB, then offset it at a distance of 41.2mm, next select line CD offset it at a distance of 1mm or 1.5 mm above it. repeat the same for entire height of sec wndg as in fig(a). Hatch it as shown in fig (b).



Fig(a)



Fig(b)

### **Step 7: To draw disc type winding for primary:**

Height of primary wndg is = 40 cm = 400mm

Thickness or height of insulation = 0.5cm(top) + 0.5 cm(bottom)  
= 1cm = 10mm

Height of each disc type wndg =  $(400\text{mm} - 10\text{mm}) / 9$

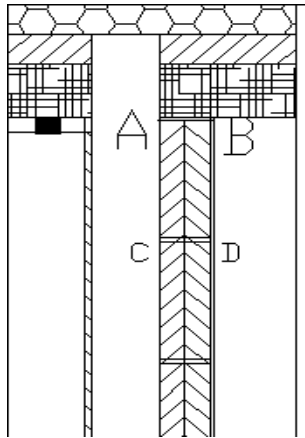
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$$= 390/9$$

$$= 43.3\text{mm}$$

Consider primary wndg,

----->>>Offseted line at a distance of 0.2cm (or 2mm) from reference line & hatch it as shown  
----->>>reference line

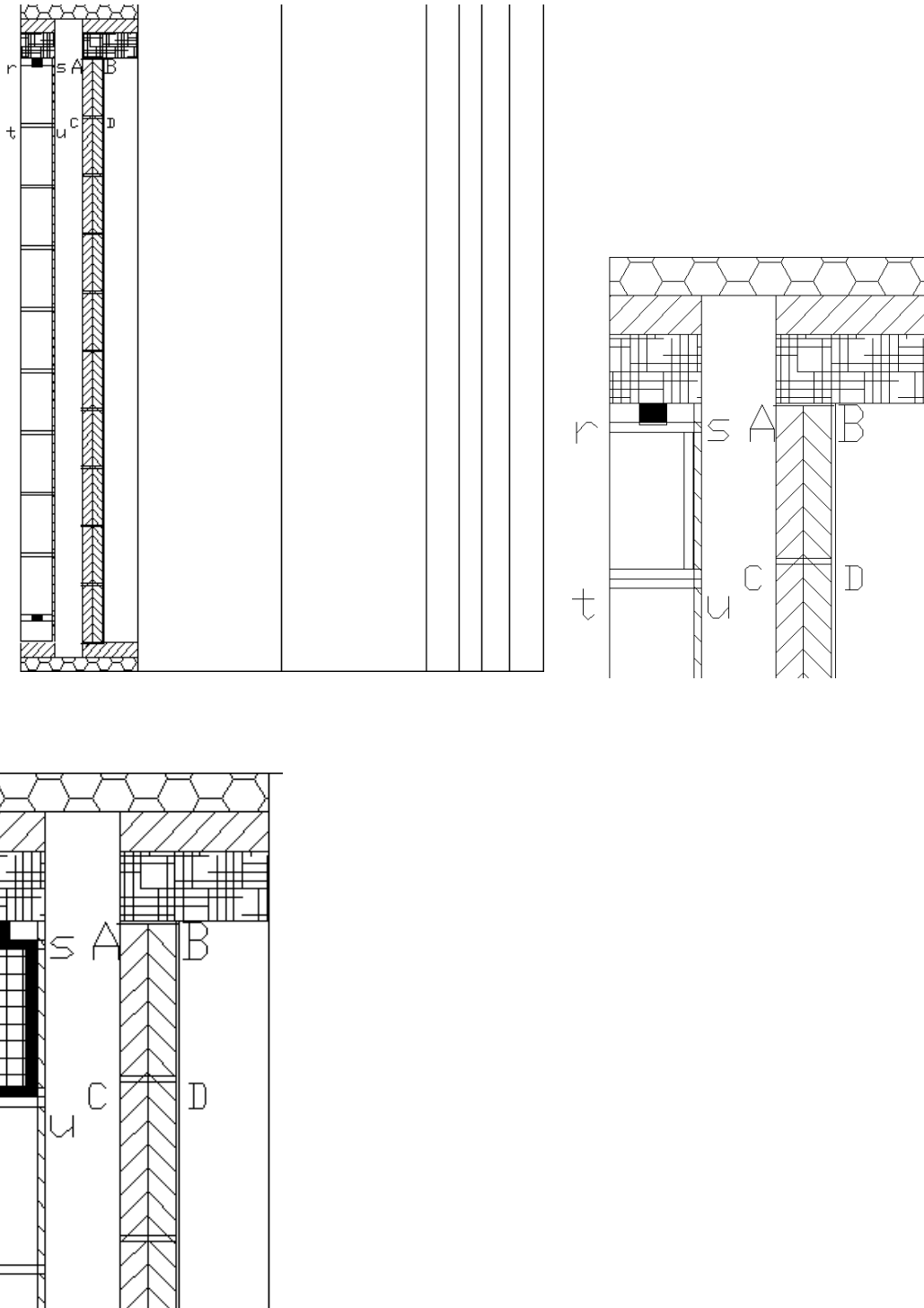


**To draw insulation at top & bottom: draw a rectangle of height of 0.5cms (5mm) & hatch it & place it appropriately as shown above in fig(3)**

**To draw disc type wndg:**

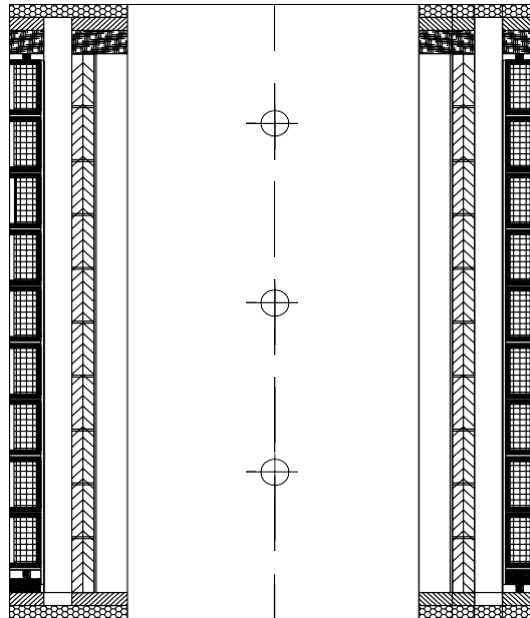
- Select line **rs** offset it at distance of 43.3mm which is the height of each disc type wndg, so that line **tu** is obtained .Offset the region of pri wndg so that 9 U shaped coils are obtained..
- Next offset the line **tu** above at a distance of 2mm or 2.5mm to include the spacer as in fig(4)
- Select the block **rstu**, offset the 3 sides of block at a distance of 2.5mm as in fig(5).Then hatch it solidly
- Inside this U shaped disc hatch it as shown fig (6)
- Copy the disc type winding & place it appropriately

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Once primary & secondary winding is drawn ,using mirror command, place the pri& sec wndg on right half of elevation as shown

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### **PROBLEM 3 :**

Draw the detailed drawing of each part separately for a 500KVA, 6600/400V single phase power transformer & then full assembled sectional plan & elevation

Detailed dimensions of parts:

**Core:** Laminated steel plates of 0.35mm thickness , core cruciform

Diameter	=33cm
Width of the largest stamping	=28cm
Width of the smallest stamping	=17.5cm
Height of core , H	= 43cm
Centre to centre distance between cores	= 49cms

Core laminations are fixed by means of two end plates 3mm thick by a bolt of dia 1.2cm

**Yoke:** construction cruciform

Yoke height	=25cm
Yoke length	=49+0.85*33 =77cm
Total height of transformer	=93cm

**Winding:**

**LV winding :**(placed near the core) helical type

LV winding total turns	=22
No. of turns per limb	=11
LV winding conductors cross section made from 20 square straps of size 5*5mm & with insulation 5.5*5.5mm	=500sq.mm
Height of 1 turn	= 28.5mm
Radial thickness of 1 turn	=23mm
Total height of the core occupied by the LV winding	=36.2cm
Inside dia of LV winding	=33.75cm

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Outside dia of LV winding	=38.35cm
<u>HT winding:</u> (in two layers)“concentric type”	
Total no. of turns	=378
No. of turns per limb	=189
Cross section of HT conductor made from made from one rectangular size strap of size 3*9mm	=27sq.mm
Inside dia of HT 1st layer	=41.5cm
Outside dia of HT 1 <sup>st</sup> layer	=43.3cm
Inside dia of HT 2nd layer	=45cm
Outside dia of HT 2 <sup>nd</sup> layer	=46.8cm

**Solution:**

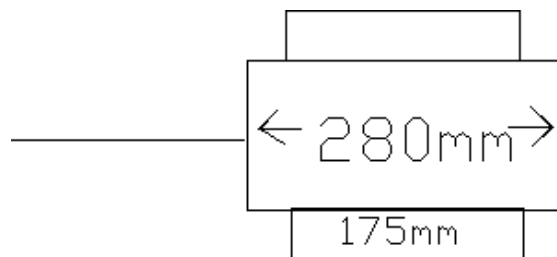
**Given:**

2 stepped core

Width of larger stamping= 28cm=280mm

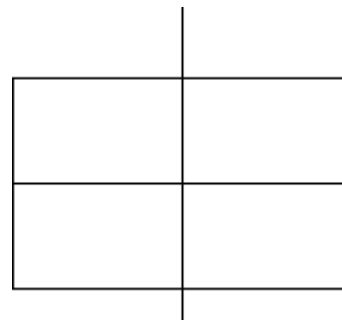
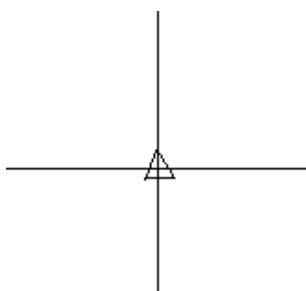
Width of smaller stamping=17.5cm=175mm

**To draw sectional plan:**



**Step1: To draw 2 stepped core**

1. Set limits
2. Type line, keeping polar status bar in ON mode
3. Draw a line @280<0, then by obtaining midpoint on this horizontal line draw a vertical reference line as shown in fig(a)
4. Offset the horizontal line by 87.5mm on both sides. Join the lines as shown in fig(b)

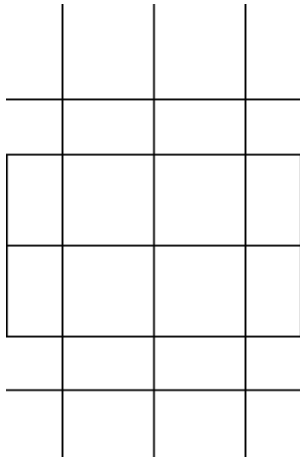


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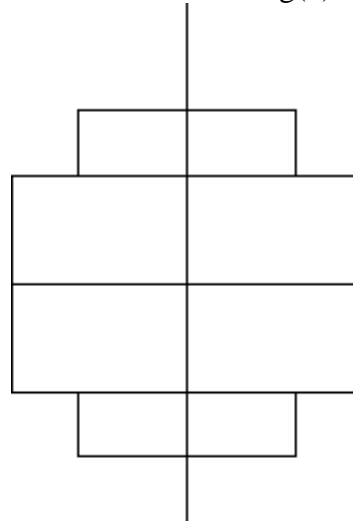
Fig(a)

fig(b)

5. Next offset the horizontal line by 140mm on both sides
6. Offset vertical line by 87.5mm on both sides as in fig(c)
7. Select the proper cutting edges & trim the unwanted lines as shown fig(d)



Fig(c)



fig(d)

### **Step 2: To draw inner & outer dia for LV & HV winding**

- Type 'circle' in the command prompt
- Specify the centre point
- Specify the radius of the circle or diameter: Type 'D' & press enter
- Specify dia of circle : 33cm=330mm

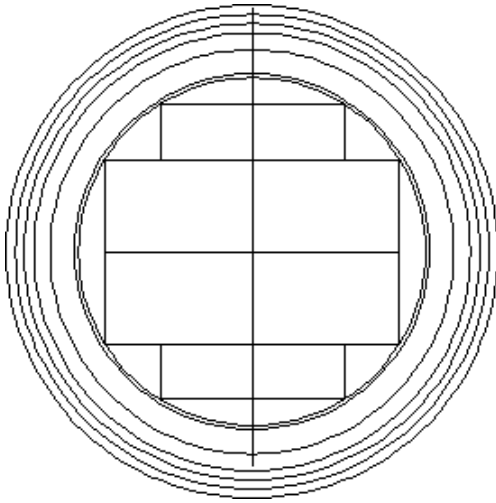
Repeat the above 4 steps to draw inner & outer dia of LV & HV wndg with following details as shown in fig(e)

Inner dia of LV= 337.5mm  
 Outer dia of LV= 383.5mm  
 Inner dia of HV 1<sup>st</sup> layer = 415mm  
 Outside dia of HV 1<sup>st</sup> layer = 433mm  
 Inner dia of HV 2<sup>nd</sup> layer = 450mm  
 Outside dia of HV 2nd layer = 468mm.

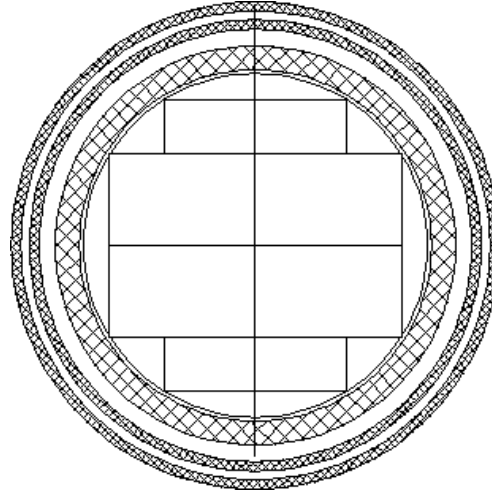
### **Step3: Hatching**

Select hatch icon, select the pattern of hatch, then hatch LV & HV wndg as shown in fig(f)

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Fig(e)

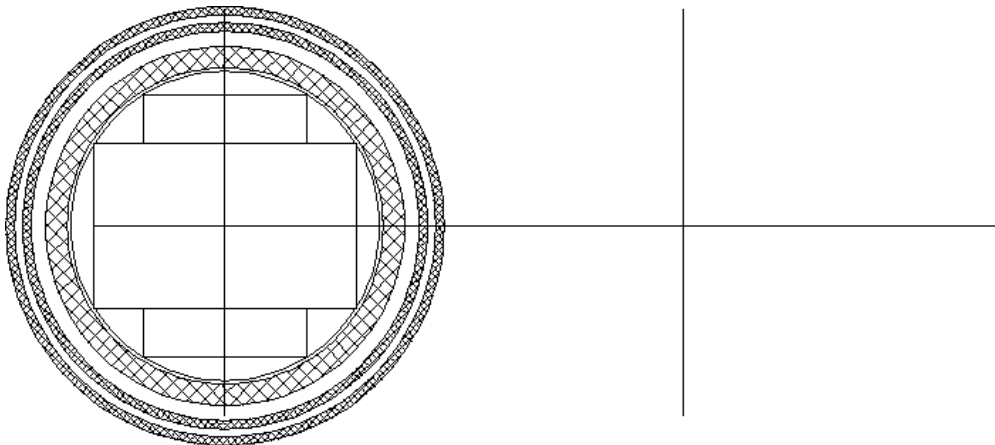


Fig(f)

### **Step 4:**

Given centre to centre distance of the core = 490mm

- Offset the vertical line at a distance of 490mm
- Extend the horizontal reference line as in fig(g)
- Using copy command , copy the entire core by specifying the base point as shown & place it at the reference point O.
- This completes the sectional plan of transformer as in fig(h)

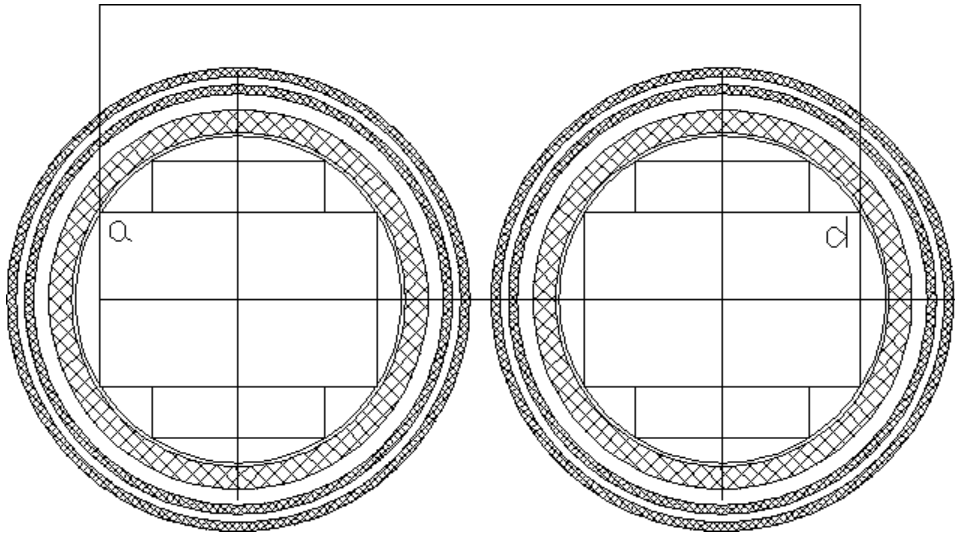


Fig(h)

### **Step5: To draw sectional elevation**

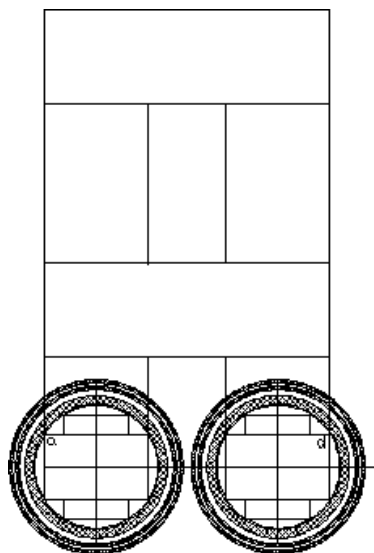
- Extend or project the lines from the point a & from the point d vertically upwards, draw a horizontal line to join the extended lines as shown in fig(h)

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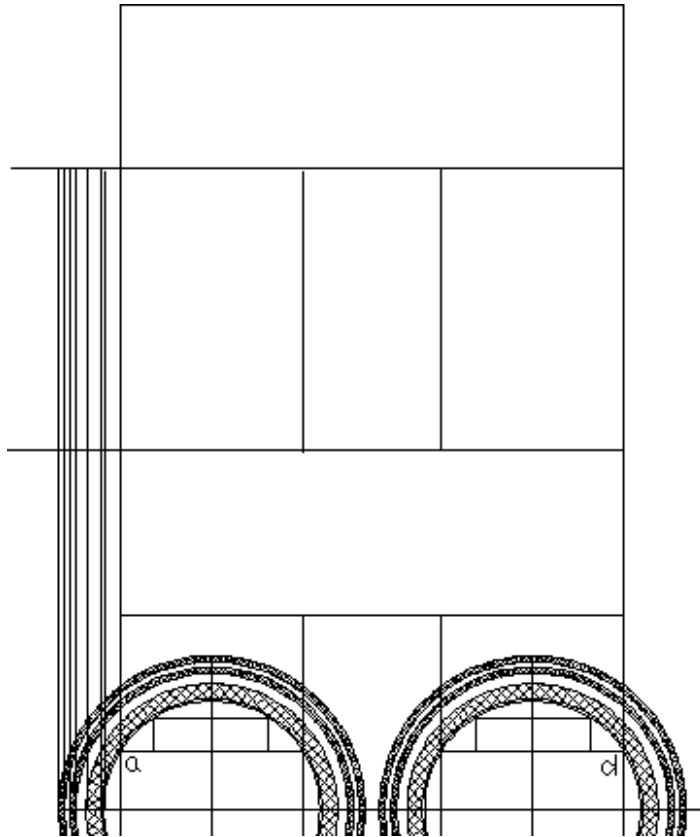
Fig(h)

- Offset the horizontal line above at a distance of 250mm(height of yoke)
- Next offset the 2<sup>nd</sup> horizontal line at a distance of 430mm(height of core) above
- Next offset the 3<sup>rd</sup> horizontal line at a distance of 250mm(height of yoke) above as in fig(i)



- Project the points from LV & HV(2 layers) wndg, 2 stepped core to carry out elevation as shown

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**Step6:** Using text command write the height (dimensions) of LV & HV windg

**Step 7:** Refer problem 2 to provide insulations using offset command at top & bottom

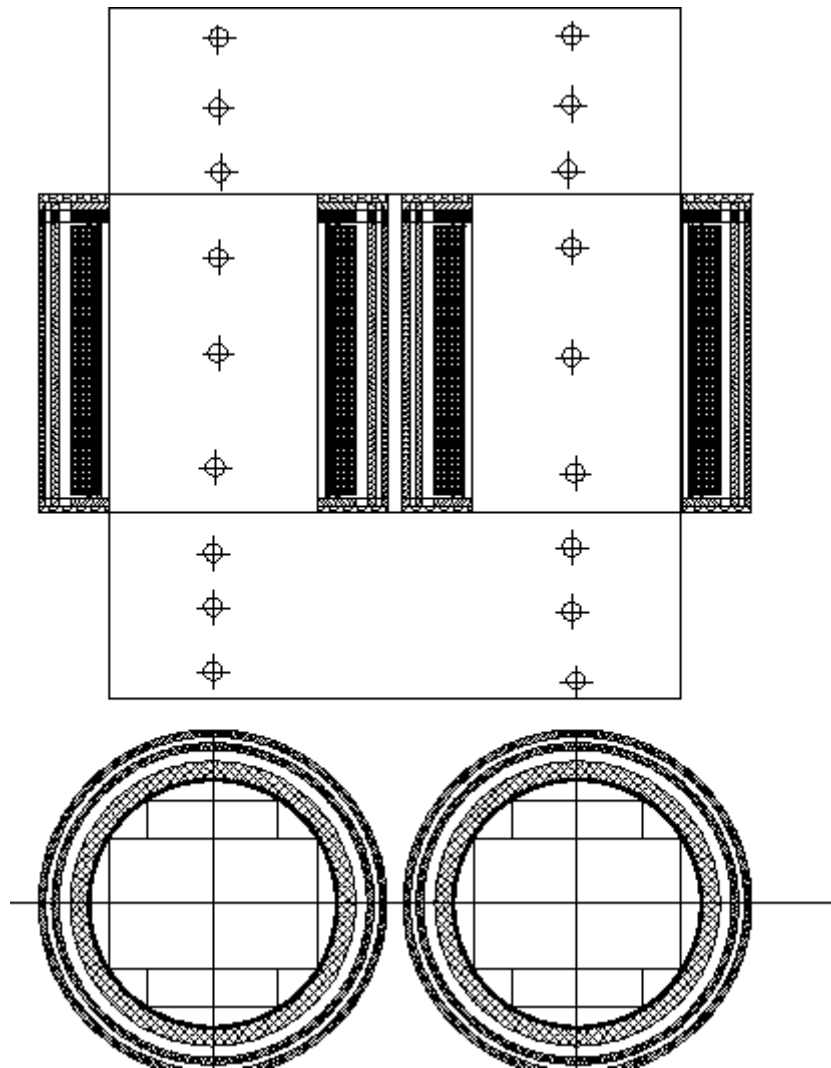
**Step 8:** To represent the type of wndg for LV& HV with respect to elevation

- Given: height of LV wndg=36.2cm=362mm
- Type of LV wndg= helical
- No. of turns/ limb= 11
- Similar to 2<sup>nd</sup>prblm, draw 11 coils of height(362/11 =32.9mm) using offset command, between each coil provide spacing of 1mm, next hatch it as shown
- Next hatch the 2 layers of HV wndg in the elevated part

**Step9 :** Select the elevated winding part, using mirror command place it on right half section for 1<sup>st</sup> core.

Next copy & paste the elevated part represented with winding for the 2<sup>nd</sup> core

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### **PROBLEM 4:**

Draw the sectional elevation of single phase shell type transformer for the given below dimensions:

Core width	=14cm
Core depth	=37cm
Core height	=38cm
Core length	=54cm
Window size	= 13*24cm
LV coil	= 4
HT coil	= 4
No. of turns in LV per coil	=10
No. of turns in HT per coil	=40
Cross section of the HT conductor	=28sq mm
Average height of one turn	=1.8cm
Coil to be arranged over medium reactance	

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**Solution:**

**Step1:**

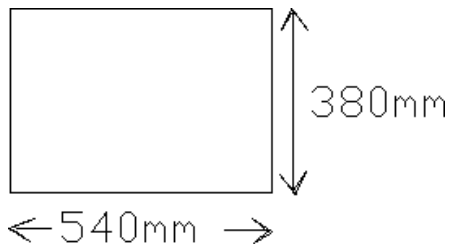
**Set limits**

- Lower left corner 0,0
- Upper right corner 2500,2500
- Zoom
- Type "ALL"
- Set the units to millimeters

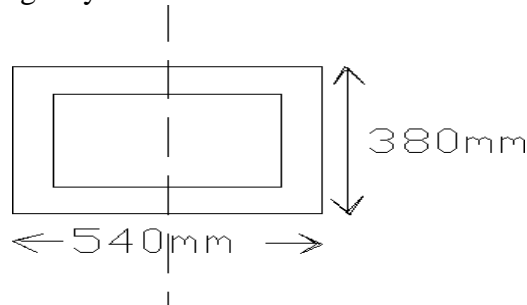
**Step 2:**

**Draw rectangle of dimension 540mm,380mm**

- Select 'rect' icon
- Select a point on screen
- It displays "Area/dimension/rotation" in the command window
- Type "D"
- Length of rectangle=540
- Width of rectangle=380
- Click on screen we get

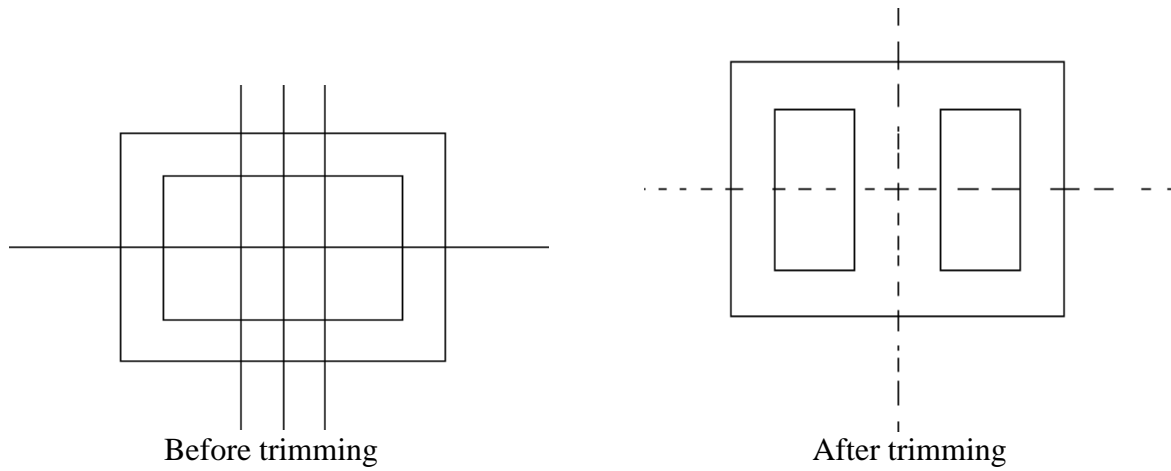


**Step 3: a) Offset rectangle by 70mm & draw a reference mid axis as shown**



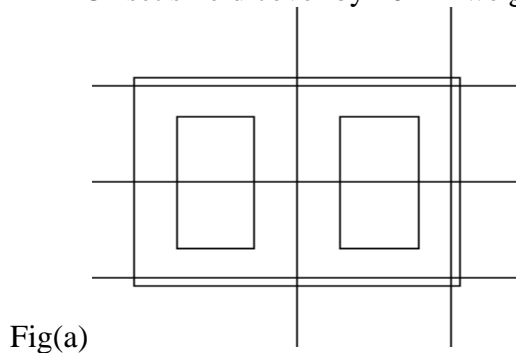
**b) Offset vertical mid axis on either side by 70mm & trim we get & also draw horizontal axis as shown below**

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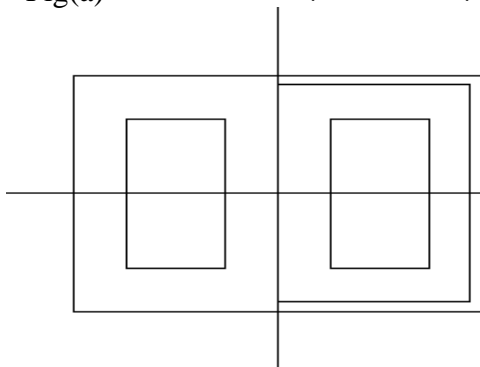


### Step 4: To draw end shield plate:

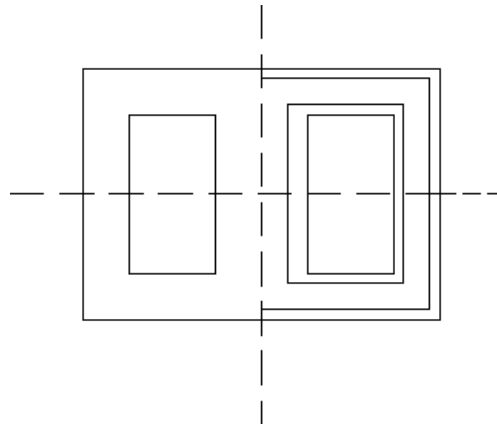
- Offset vertical reference line by  $510/2=255\text{mm}$
- Offset horizontal reference line by  $350/2=175\text{mm}$  as in fig(a) before trimming
- Fig(b) shows the diagram after trimming
- Offset shield cover by 40mm we get (all sides) as in fig(c)



Fig(b)



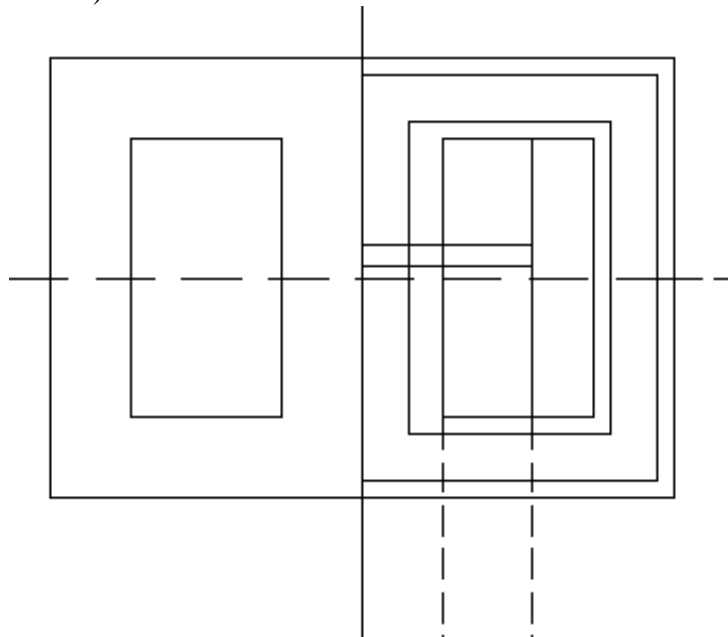
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Fig(c)

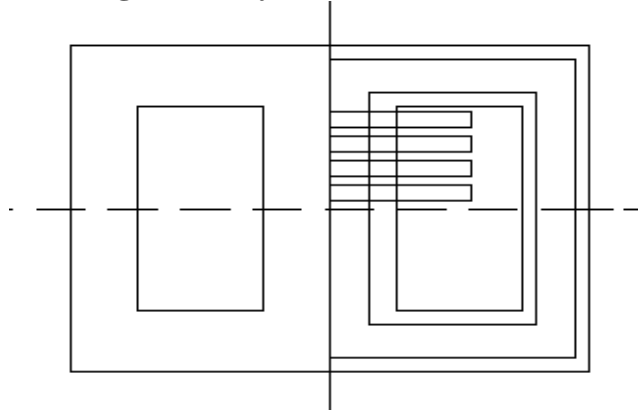
### Step 5:

- Offset right side of window by 76mm(length of coil)
- From horizontal axis:
  - a) Offset 10.1mm(clearance)
  - b) Offset 18mm(width of coil)
  - c) Then Trim as shown below



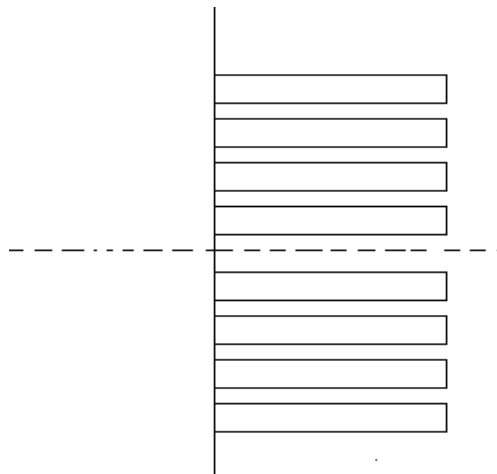
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### Step6: Array the coil: Rectangular array



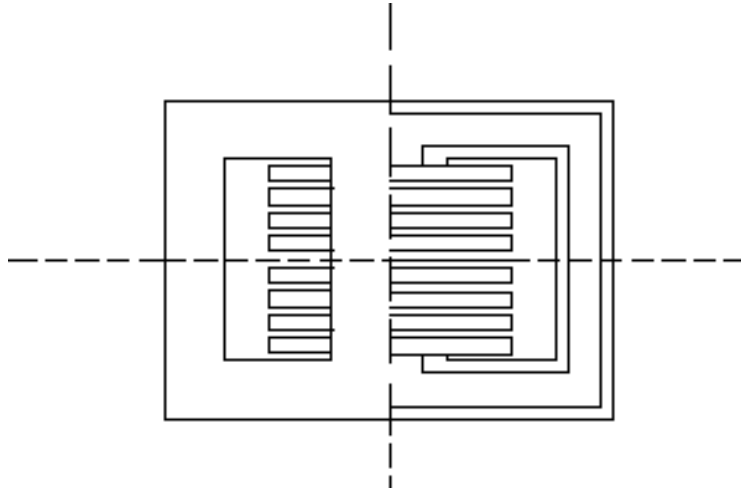
- Row=4
- Column=1
- Row offset=28.1(18mm thickness of coil+ 10.1 clearance)
- Column offset=1
- Select the object
- Click ok then diagram appears as shown above

### Step 7: Mirror down we get



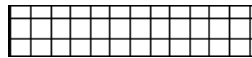
### Step 8: Mirror to the left side of window & after trimming we get

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### Step 9: Arrangement of LV & HV winding

**LV:** use “Net” pattern in hatch , select scale as 100 as shown below

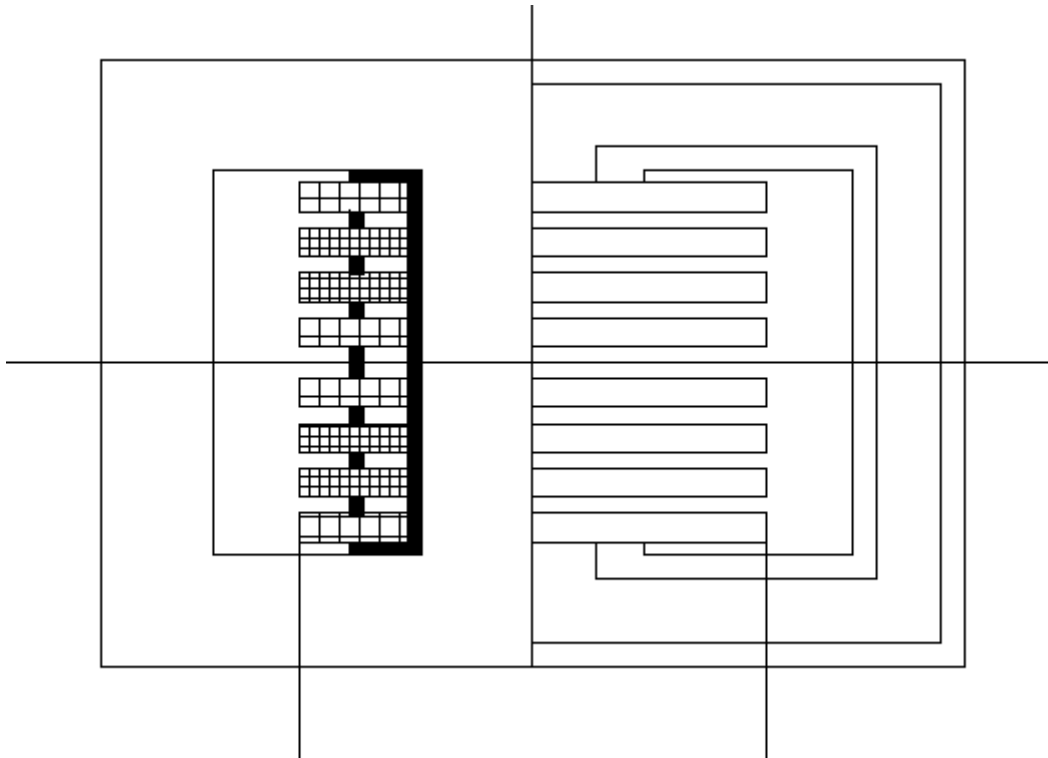


**HV:** Use “Net” in hatch command, select scale as 50



**Over all arrangement of LV & HV winding & insulation thickness of 10mm is shown below : (project the lines downwards for elevation as shown below )**

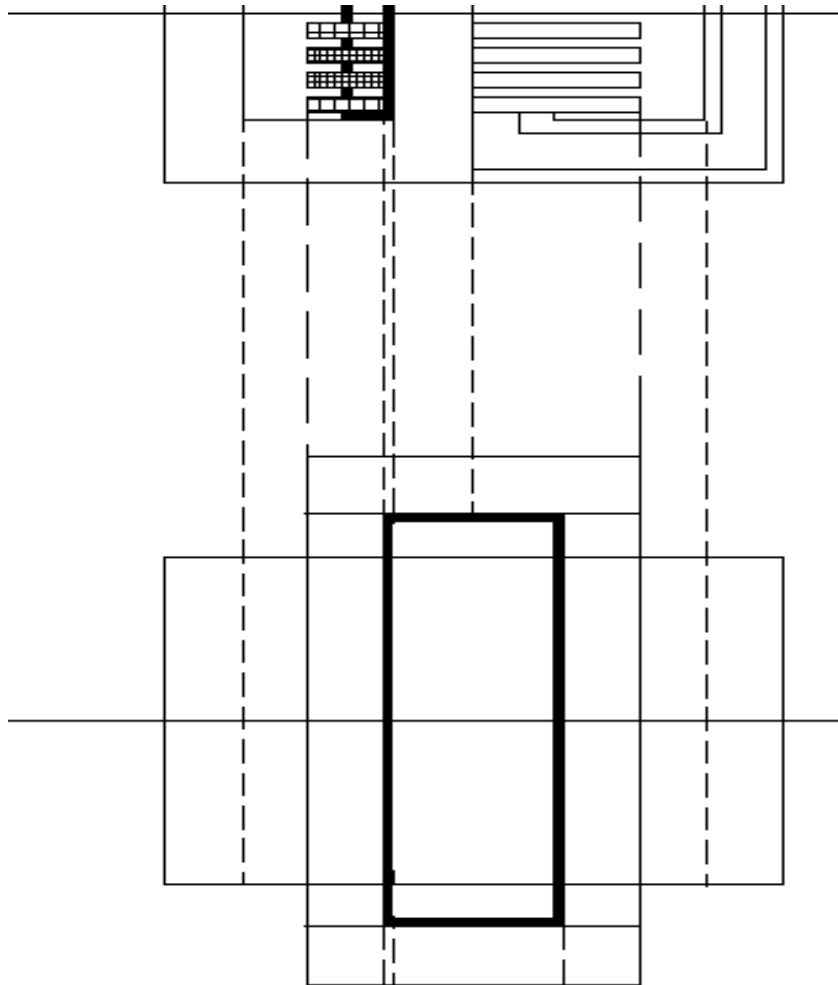
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### Step 10: To draw elevation:

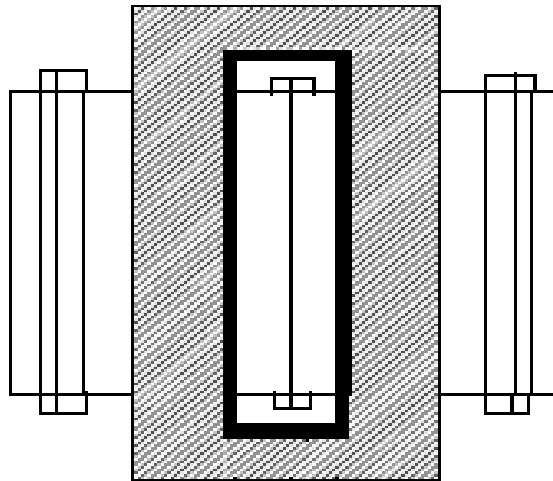
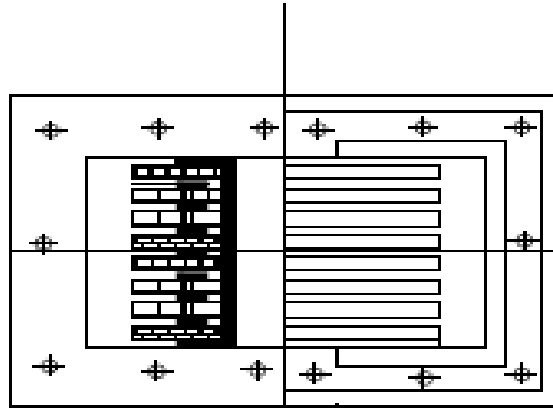
- Draw a rectangle of dimension 540\*370mm
- Project the coils down as shown below
- Coil length=76mm
- Assume insulation as 10mm, then length of coil=76-10=66mm
- Hatch the coil & insulation with the patterns:
  - ✓ ANSI37
  - ✓ Solid

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**Step11:** place the bolts and nuts on both sides.

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**Outcome:** students will be able to draw and visualise the sectionals views of various kinds of transformers