$$U_{\substack{cap \\ stored}} = \frac{1}{2} C V^2$$

$$U_{\substack{Ind \\ stored}} = \frac{1}{2} L i^2$$

$$U_{\substack{density \\ cap}} = \frac{U_{stored}}{Vol} = \frac{1}{2} K \epsilon_0 E^2$$

$$U_{\substack{density \\ Ind}} = \frac{U_{stored}}{Vol} = \frac{1}{2\mu_0} B^2$$

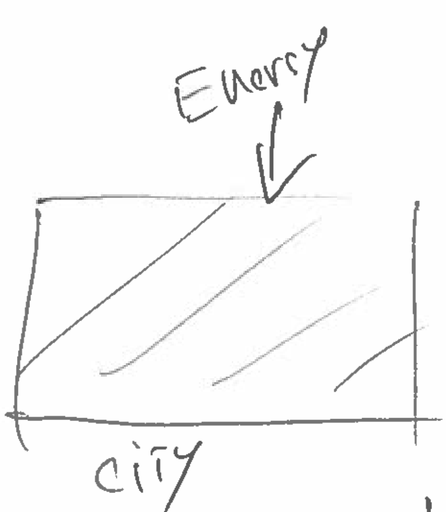
22-49

what is maximum energy stored in space above a city.

$B_{Earth} = 7.0 \times 10^{-5}$ T

$A_{city} = 5.0 \times 10^{8}$ m^2

$H_{city} = 1500$ m

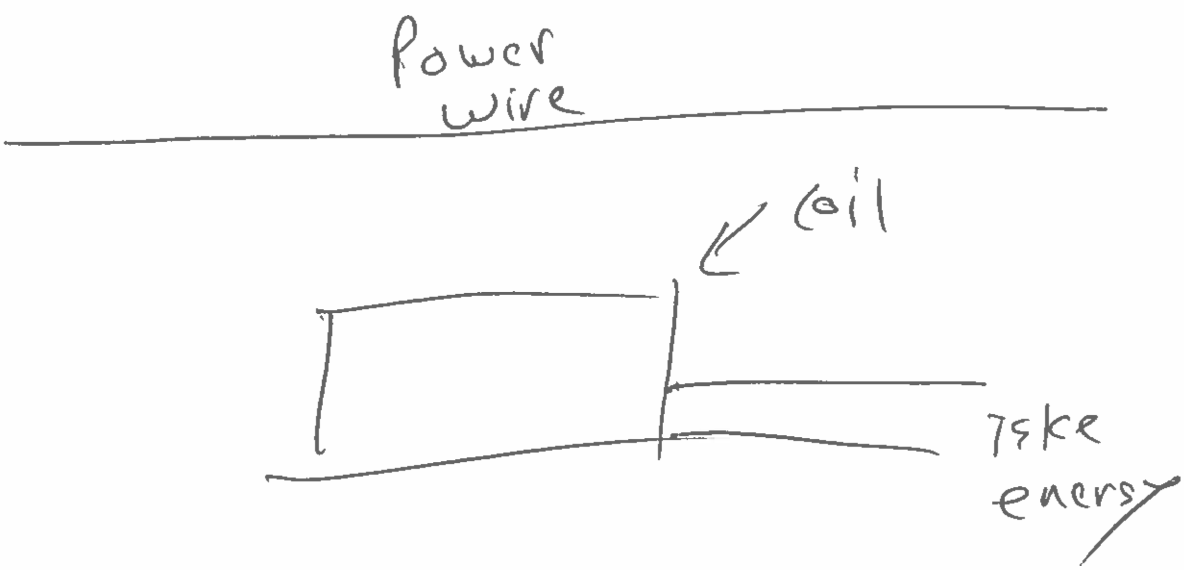


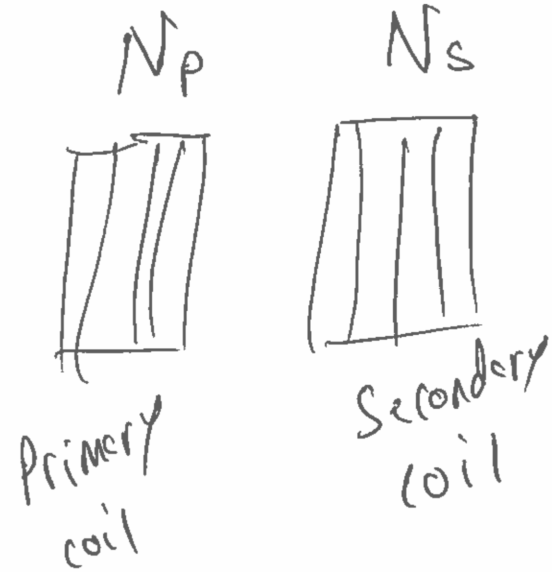
$$U_{stored} = U_{density} \, Vol$$

$$U_{stored} = \frac{1}{2\mu_0} B^2 A_{city} H$$

$$U_{\substack{\text{stored}\\\text{above}\\\text{city}}} = \frac{1}{2\left(4\pi \times 10^{-7}\,\frac{\text{T m}}{\text{A}}\right)}\left(7.0 \times 10^{-5}\,\text{T}\right)^2 \times \left(5.0 \times 10^{8}\,\text{m}^2\right)(1500\,\text{m})$$

$$U_{\substack{\text{stored}\\\text{above}\\\text{city}}} = 1.5 \times 10^{9}\,\text{J}$$





Mutual Inductance

Primery coil creates magnetic field which Interacts with secondery coil creating $\mathcal{E}_s$

$$\mathcal{E}_s = -N_s \frac{\Delta \Phi_p}{\Delta t}$$

Primery coil also self-inducts

$$\mathcal{E}_p = -N_p \frac{\Delta \Phi_p}{\Delta t}$$

$$\frac{\mathcal{E}_s = -N_s \frac{\Delta \Phi_p}{\Delta t}}{\mathcal{E}_p = -N_p \frac{\Delta \Phi_p}{\Delta t}}$$

Transformer equation

$$\frac{\mathcal{E}_s}{\mathcal{E}_p} = \frac{N_s}{N_p}$$

If $N_s > N_p \Rightarrow$ step-up transformer

If $N_s < N_p \Rightarrow$ step-down transformer

$$\frac{N_s}{N_p} = 50 \quad \Rightarrow N_s = 50\, N_p$$

put 10V into primary

$$\mathcal{E}_s = \mathcal{E}_p \frac{N_s}{N_p} = (10\,V)(50)$$

$$\mathcal{E}_s = 500\ V$$

Power cannot change except to lose a little.

$$P_p = P_s$$

$$i_p \mathcal{E}_p = i_s \mathcal{E}_s$$

$$i_s = i_p \frac{\mathcal{E}_p}{\mathcal{E}_s} = i_p \left(\frac{N_p}{N_s}\right)$$

Assume $i_p = 1A$

$$i_s = i_p \left(\frac{1}{50}\right)$$

$$i_s = (1A)\left(\frac{1}{50}\right) = \frac{1}{50} A$$

Step-up / step-down ⇒ refers to voltage not current.

$$\frac{N_s}{N_p} = \frac{\mathcal{E}_s}{\mathcal{E}_p} = \frac{i_p}{i_s}$$

$$\mathcal{E}_s = -N_s \frac{\Delta \Phi}{\Delta t}$$

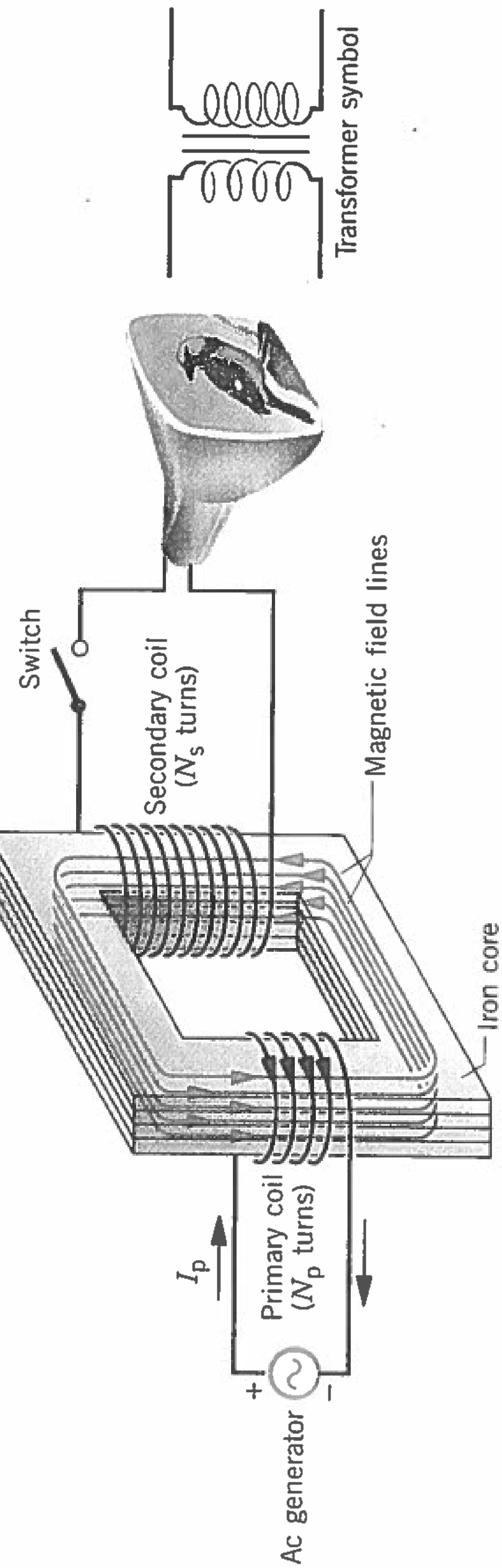


FIGURE 22.24

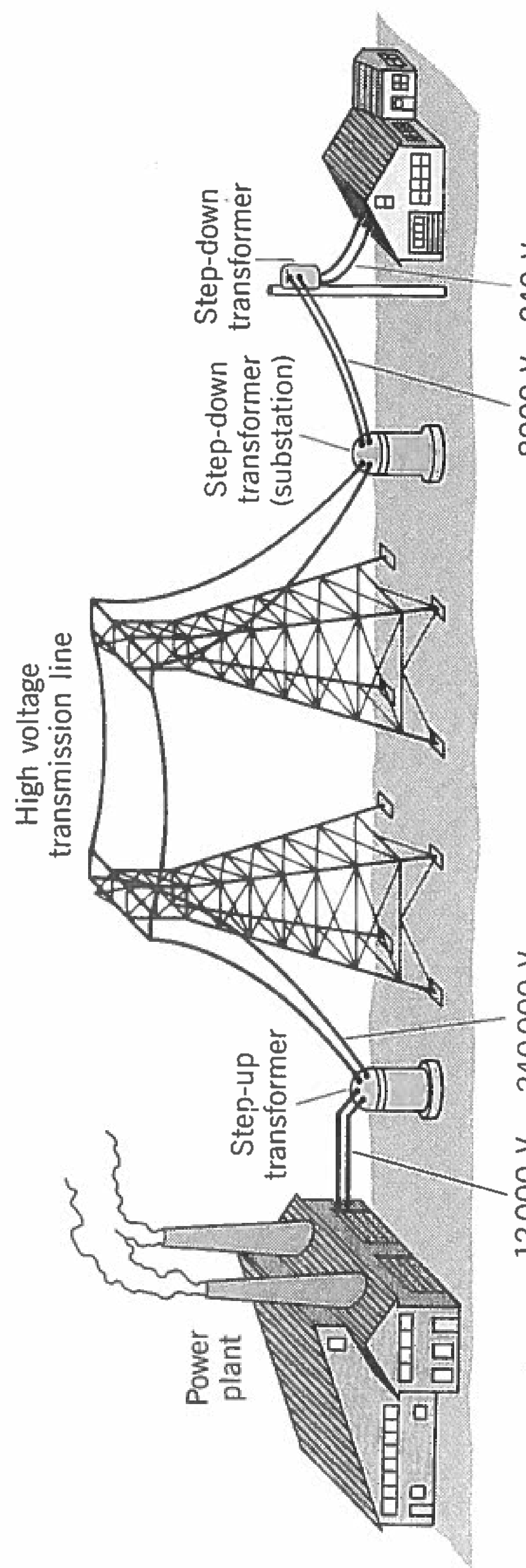

Power plant
Step-up transformer
12 000 V
240 000 V
High voltage transmission line
Step-down transformer (substation)
8000 V
Step-down transformer
240 V

FIGURE 22.25

Primary loss of Energy Transporting electricity is called Joule Heating. Heat created by current traveling along a wire

$$\text{Power lost} = i^2 R$$

eg/ $N_p = 500$ turns $\quad N_s = 30$ turns

$\mathcal{E}_p = 110V \quad \mathcal{E}_s = ?$

$$\frac{\mathcal{E}_s}{\mathcal{E}_p} = \frac{N_s}{N_p} \Rightarrow \mathcal{E}_s = \mathcal{E}_p \frac{N_s}{N_p}$$

$$\mathcal{E}_s = (110V)\left(\frac{30}{500}\right) = 6.6\ V$$

what if $i_p = 1\ A$, $i_s = ?$

$$\frac{i_s}{i_p} = \frac{N_p}{N_s} \qquad i_s = i_p \frac{N_p}{N_s}$$

$$i_s = (1A)\left(\frac{500}{30}\right) = \underline{16.67A}$$

$$P_p = i_p \mathcal{E}_p = (1A)(110V) = \underline{110W}$$

$$P_s = i_s \mathcal{E}_s = (16.67A)(6.6V) = \underline{110W}$$

$$P_p = i_p \mathcal{E}_p = P_s = i_s \mathcal{E}_s$$

$$i_s = i_p \frac{\mathcal{E}_p}{\mathcal{E}_s} = (1A)\frac{(110V)}{6.6V}$$

$$\underline{i_s = 16.67\ A}$$

22-61

Turns ratio = 50 : 1 $\quad N_S : N_P$

$\mathcal{E}_p = 120V \qquad i_s = 1.7 \times 10^{-3} A$

$P_s = ? \qquad V_s$

$P_s = i_s \mathcal{E}_s \qquad \frac{\mathcal{E}_s}{\mathcal{E}_p} = \frac{N_s}{N_p}$

$$\mathcal{E}_s = \mathcal{E}_p \left(\frac{N_s}{N_p}\right)$$

$$P_s = i_s \mathcal{E}_p \left(\frac{N_s}{N_p}\right)$$

$$= (1.7 \times 10^{-3} A)(120V)(50)$$

$$\underline{P_s = 10.2\ W}$$

22-62

$\mathcal{E}_s = 9.0\,V \qquad i_s = 225\,mA$

$\mathcal{E}_p = 120\,V$

Turns ratio ?

$i_p = ?$

$P_{from\ wall} = ?$

$P_{BATT} = ?$

$$\frac{N_s}{N_p} = \frac{\mathcal{E}_s}{\mathcal{E}_p} = \frac{9.0\,V}{120\,V}$$

$$\frac{N_s}{N_p} = \frac{1}{13.33}$$

Turns Ratio = 1 to 13

$$\frac{i_p}{i_s} = \frac{N_s}{N_p} = i_s\left(\frac{N_s}{N_p}\right) = \frac{225\times10^{-3}\,A}{(13)}$$

$$i_p = 17.3\times10^{-3}\,A = 17.3\,mA$$

$$P_{wall} = i_p\mathcal{E}_p = (17.3\,mA)(120\,V) = 2.08\,W$$

$$P_{batt} = i_s\mathcal{E}_s = (225\,mA)(9.0\,V) = 2.03\,W$$