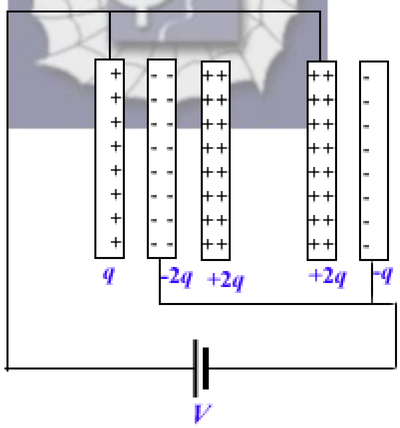
363.

<u>Problem 31.17 (RHK)</u>

In the figure line diagram has been drawn of a air capacitor. Alternate plates are connected together. We consider a pile of n plates of alternate polarity, each having an area A and separated from adjacent plates by a distance d. We have to show that this capacitor has a maximum capacitance of

$$C = \frac{(n-1)\varepsilon_0 A}{d}.$$



<u>Solution:</u>

In the configuration shown in the figure if the left-hand outer plate has charge +*q*, the right-hand outer plate will have charge –*q*. Each of the inner plates will have charge -2*q* or +2*q*, alternately as shown. This is required for the field between the plates to be uniform and the alternate plates to have the same polarity. The total +ve charge on the plates of the condenser connected to the +ve terminal of the battery will be

$$q+2q\left(\frac{n}{2}-1\right)=q(n-1)\ .$$

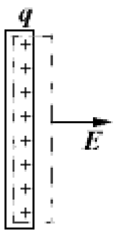
And the total negative charge on the plates will be

$$-q(n-1).$$

Let V be the potential difference across the external source of *EMF*. The magnitude of the electric field between any pair of plates will be

$$E=\frac{V}{d}.$$

By applying Gauss theorem across any plate as shown,



we note that

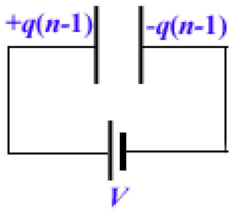
$$\varepsilon_0 EA=q,$$

or

$$E=\frac{q}{\varepsilon_0 A}=\frac{V}{d}.$$

And

$$q=\frac{\varepsilon_0 AV}{d}.$$



The capacitance of the combination C will be determined by the requirement that effectively we have a parallel plate capacitor in which charges on the plates is $+q(n-1)$ and $-q(n-1)$, and potential difference across them is V.

$$\therefore \; q(n-1) = \frac{\varepsilon_0 A V (n-1)}{d} = CV.$$

And

$$C = \frac{(n-1)\varepsilon_0 A}{d} \; .$$