cylinders (cylindrical capacitor).

2. Capacitance

The ability of a capacitor to store charge is known as its *capacitance*. Consider a parallel-plate air capacitor connected to a battery as shown in Fig. 6.1. The electrons from plate *A* will be attracted by the battery and these electrons start piling up on plate *B*. This action is referred to as charging of capacitor because capacitor plates are being charged. It has been found experimentally that charge q stored in a capacitor is directly proportional to the p.d. (V) across the plates *i.e.*,

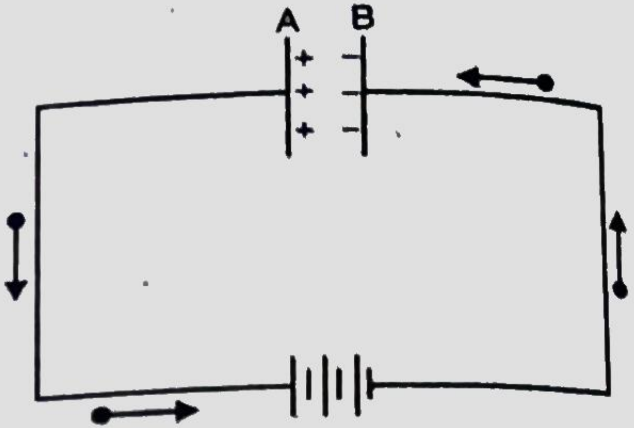

Fig. 6.1

$$q \propto V$$

or $$\frac{q}{V} = \text{constant} = C$$

The constant of proportionality C is called capacitance of the capacitor. The unit of capacitance is 1 C/V which is also called 1 farad.

$$1\ \text{C/V} = 1\ \text{farad}$$

(i) By definition, capacitance is always a positive quantity.

(ii) The p.d. across the capacitor increases linearly with increase in charge on capacitor plates. Therefore, the ratio q/V is constant for a given capacitor.

Note that exp. (*i*) represents energy ... electric field exists.
But it can be shown to be true for any region of space where electric field exists.

13. Combination of Capacitors

In some applications, we may want a capacitance that is not available commercially. However, capacitors can be connected together to form a combination that can have a capacitance close to the desired value. There are three ways of connecting the capacitors together *viz* (*i*) series capacitors (*ii*) parallel capacitors (*iii*) series-parallel capacitors.

(*i*) **Series capacitors.** The capacitors are said to be in series if charge on each capacitor is the same (*i.e.*, + q on one plate and – q on the other). Fig. 6.9 (*i*) shows three capacitors of capacitances C_1, C_2 and C_3 connected across a d.c. source of voltage V. The total capacitance C_T is given by ;

$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

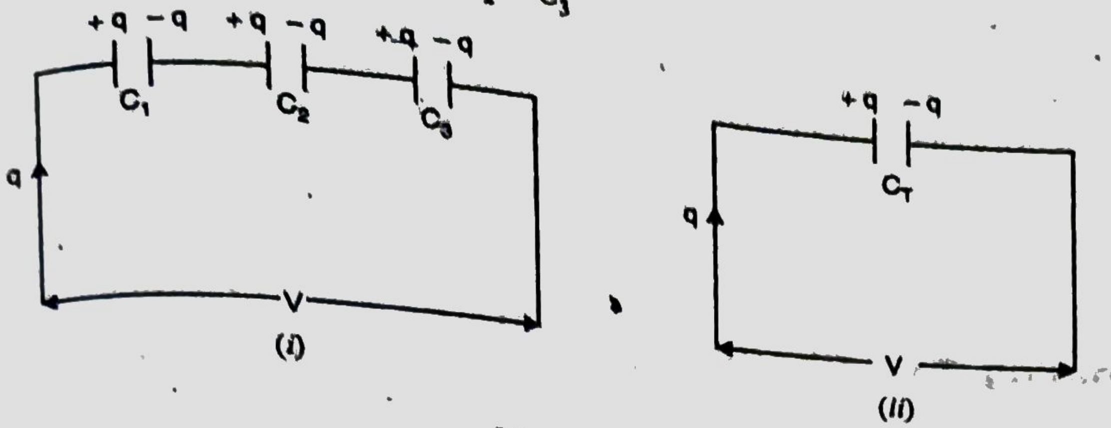

Fig. 6.9

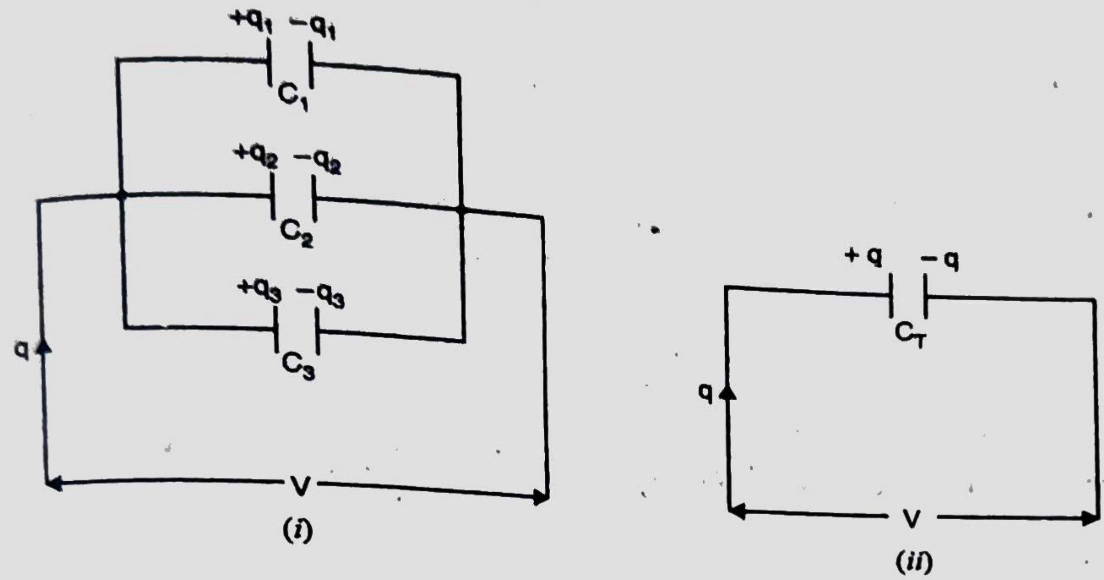

Fig. 6.10

Note that total capacitance of a series combination is always *less* than any individual capacitance in the combination.

Special case. If two capacitors of capacitances C_1 and C_2 are connected in series, then total capacitance C_T is given by ;

$$C_T = \frac{C_1 C_2}{C_1 + C_2} \quad i.e. \quad \frac{\text{Product}}{\text{Sum}}$$

(*ii*) **Parallel-capacitors.** The capacitors are said to be connected in parallel if potential difference (p.d.) across each capacitor is the same. Fig. 6.10 (*i*) shows three capacitors of capacitances C_1, C_2 and C_3 connected in parallel across a d.c. source of voltage V. The total capacitance C_T is given by ;

$$C_T = C_1 + C_2 + C_3$$

Note that total capacitance of a parallel combination of capacitors is *larger* than any of the individual capacitances.

(*iii*) **Series-parallel capacitors.** Series-parallel capacitor circuits can be solved by applying the formulas for series and parallel capacitors to the appropriate parts of the circuit. Of course, the general capacitance formula ($C = q/V$) and Kirchhoff laws can also be applied. Fig. 6.11 shows a simple series-parallel capacitor circuit. The total capacitance C_T of the circuit can be found as under :

$$C_{23} = C_2 + C_3$$

$$C_T = \frac{C_{23}C_1}{C_{23} + C_1}$$

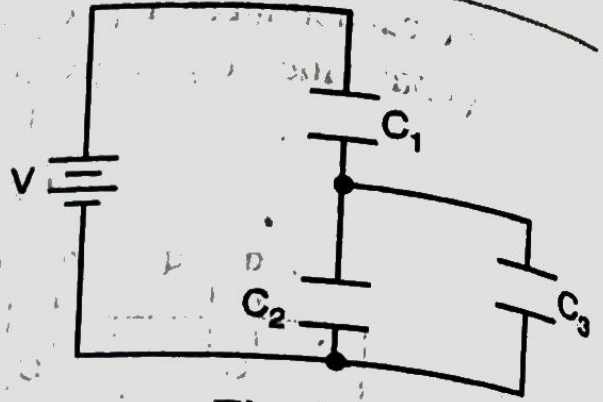

Fig. 6.11