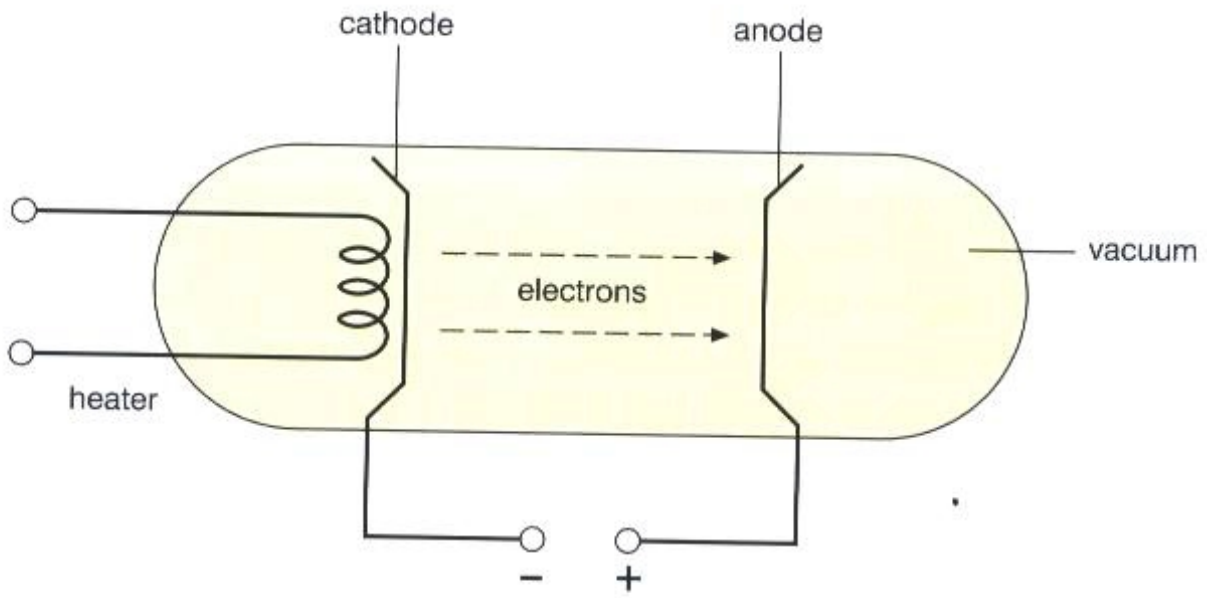
# 6 CATHODE RAY OSCILLOSCOPES

## Cathode rays

Cathode rays were discovered in the late 1800s. J.J. Thomson discovered that these rays consisted of a stream of **electrons** emitted from a heated cathode (a negative terminal).

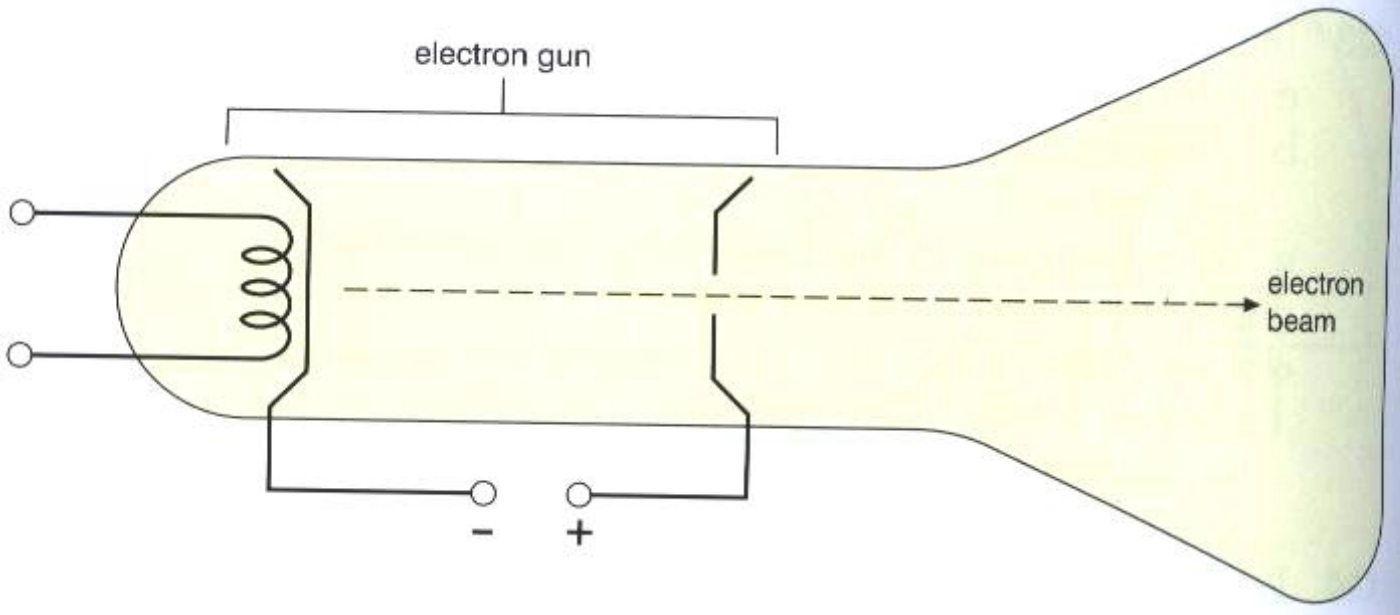



### A* EXTRA

- As the electron is accelerated between the cathode and anode, it gains kinetic energy. The energy gained is equal to $e \times V$, where e is the charge on the electron and $V$ is the voltage between the terminals.

The positive terminal (the anode) attracts the electrons from the cathode. The cathode is heated to increase the average energy of the electrons in the cathode, which means that electrons will spontaneously jump out of the surface of the metal. The process of emitting electrons from a heated cathode is called **thermionic emission.**

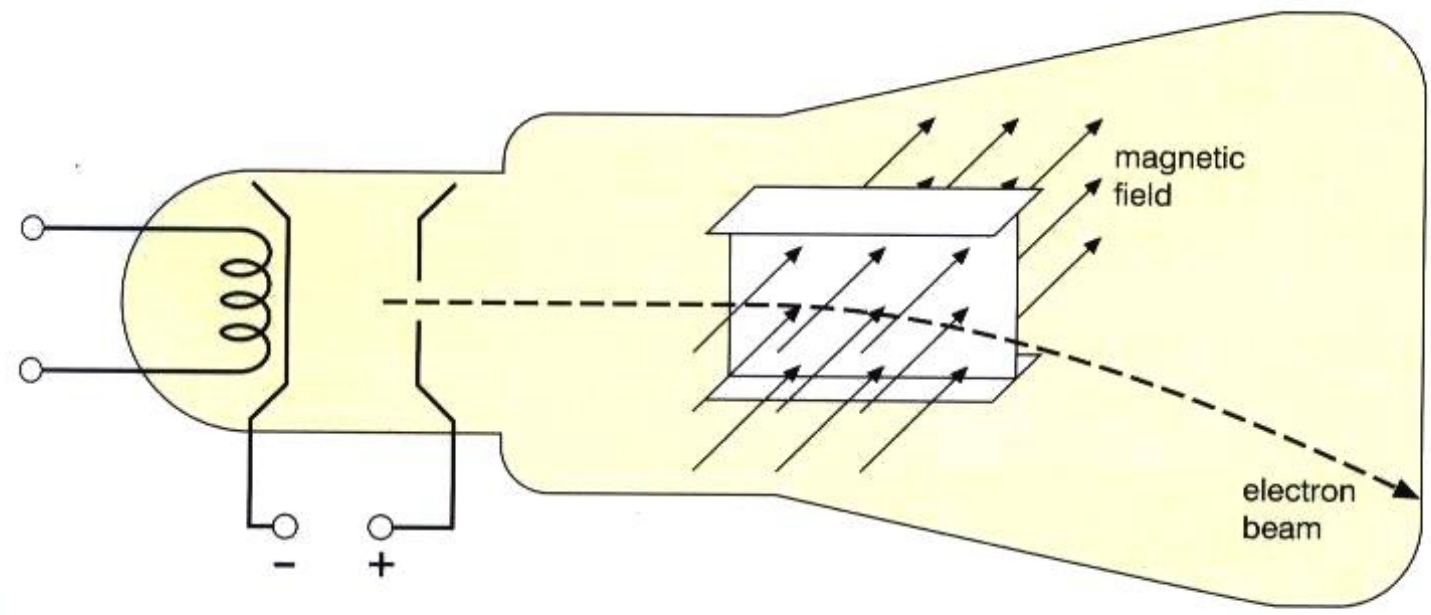
If there is a hole in the anode, a beam of electrons shoots through. The whole arrangement is then called an **electron gun.**




An electron gun.

## DEFLECTING THE BEAM

An electron beam is equivalent to an electric current, but without the wire. It can be deflected by **other electric charges** or by magnetic fields. In this diagram, the magnetic field is at right angles to the electron beam, so the beam is deflected. This is an example of the **motor effect** (see page 151). Check that it is obeying Fleming's left-hand motor rule, with First finger for Field, seCond finger for Current and thuMb for movement. Be careful over the question of which way the current is flowing.

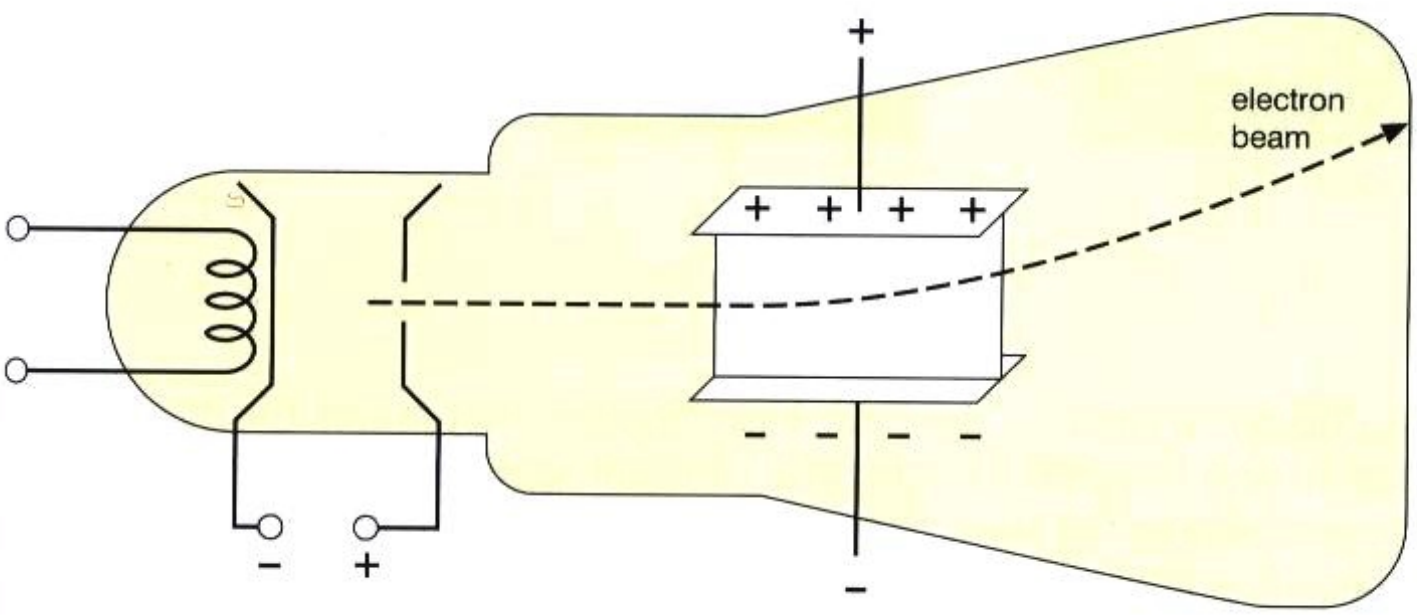



Deflecting electrons with a magnetic field.

## A* EXTRA

- The electron beam is an electric current. We can link the *number* of electrons moving per second to the *current* of the beam. Using the formula $I = \frac{Q}{t}$, if there is a current of 1.0 A, then there must be 1 coulomb of electric charge moving per second. 1 coulomb of electric charge is equivalent to $6.25 \times 10^{18}$ electrons.

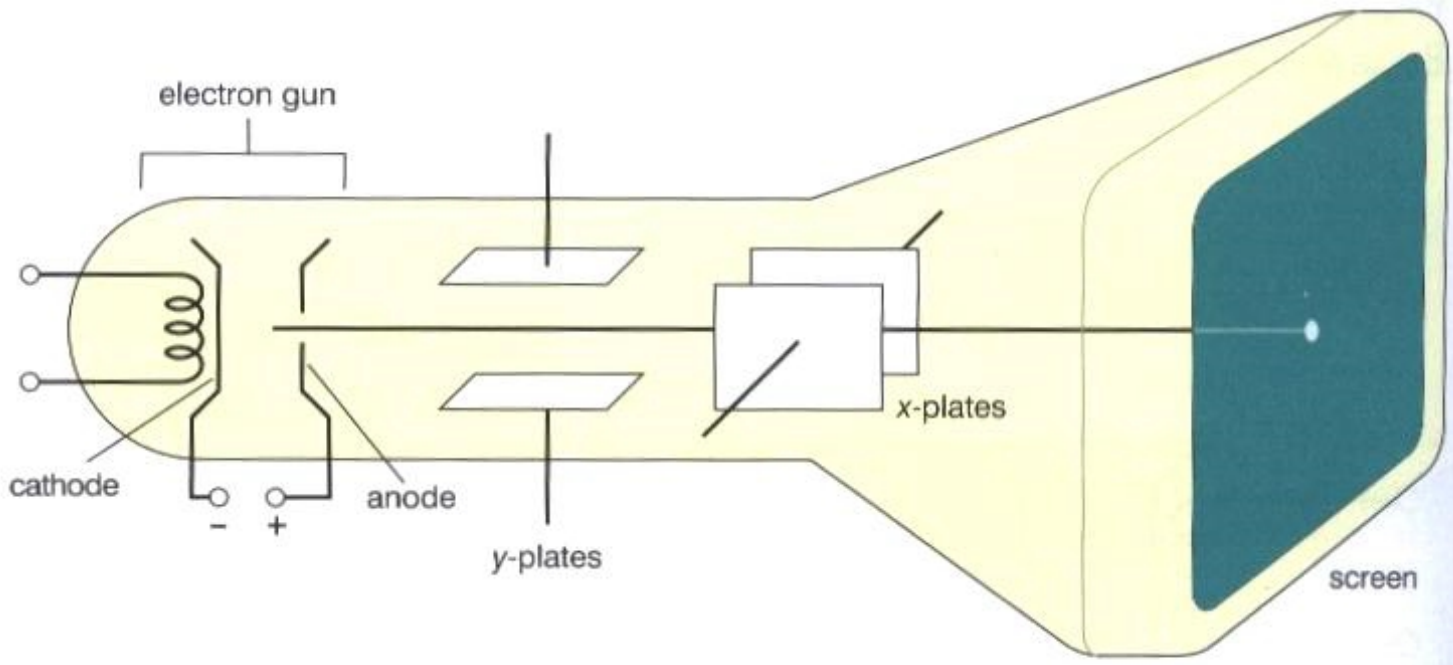
In this diagram, the metal plates are charged, attracting the electron beam towards the positive plate and repelling it away from the negative plate.




Deflecting electrons with electric charges.

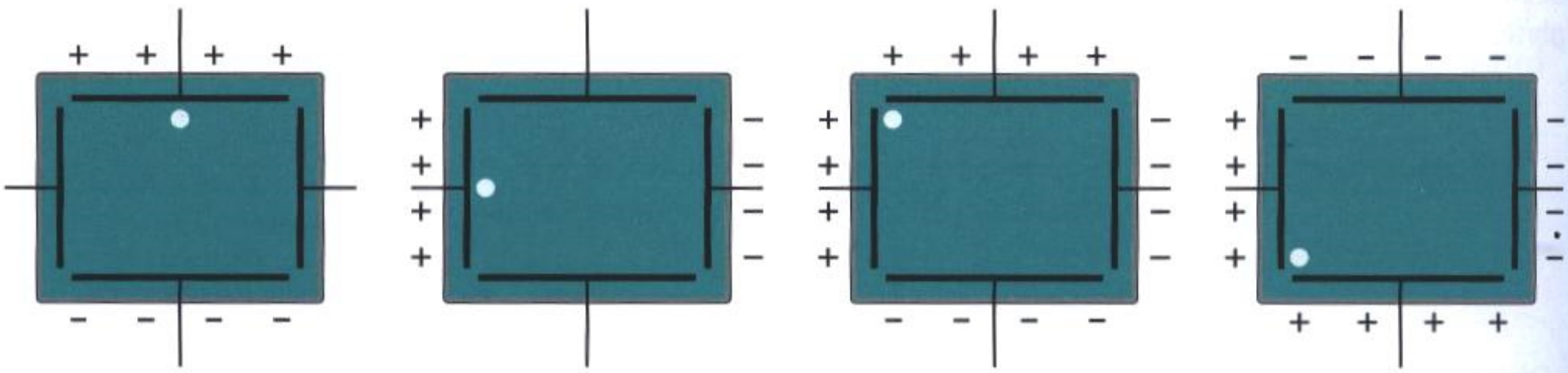
# Simple treatment of the cathode ray oscilloscope

In a cathode ray oscilloscope, CRO, the electron beam is directed towards a **fluorescent screen.** Where the beam hits the screen, the coating on the screen absorbs the energy from the electrons and releases the energy as light – a dot appears on the screen.




The cathode ray oscilloscope.

Two sets of metal plates are used to deflect the beam – one pair in the **vertical** direction (called the ***y*-plates**) and one pair in the **horizontal** direction (called the ***x*-plates**). By controlling the voltages on these sets of plates, the dot can be moved to any position on the screen.



By changing the voltages on the X- and Y-plates, the dot can be moved around the screen.

A CRO has a circuit – the **time-base circuit** – that moves the dot across the screen, from left to right, at a constant speed and then returns the dot very quickly to the start. Repeating this process quickly means the dot appears as a **line** across the screen.

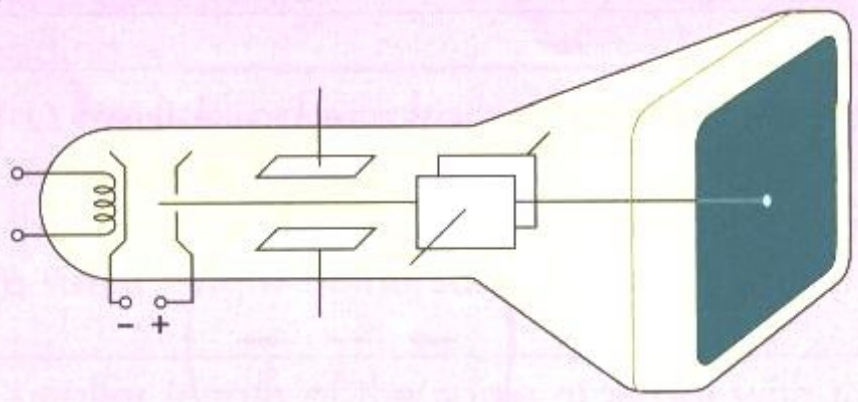
A CRO can be used as a very high resistance voltmeter. If an unknown voltage is connected to the *y*-plates, the deflection produced in the beam can be compared to reference measurements and a value for the voltage obtained.

With the time-base circuit switched on and a variable signal connected to the *y*-plates, a CRO can be used to show how a waveform varies. This can be used to measure the frequency of a signal.

## REVIEW QUESTIONS

**Q1** What is thermionic emission?

**Q2** The diagram shows a CRO. Copy the diagram and add the labels in the correct places.
*screen* *x-plates* *y-plates* *anode* *cathode* *electron gun*

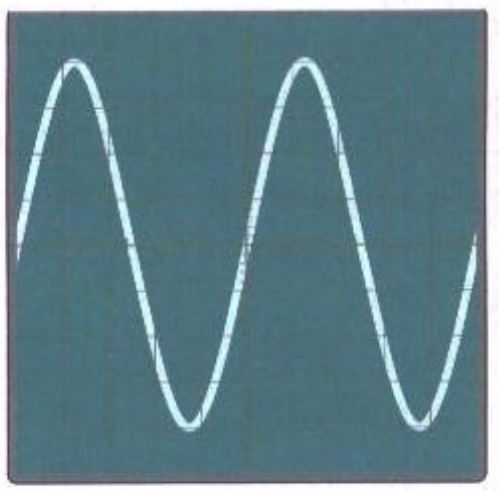



**Q3** The diagram shows a trace on a CRO screen. The vertical setting is 0.2 V per division (square) and the timebase setting is 10 ms per division (square).
10 ms = 0.01 s.

**a** What is the amplitude of the signal in volts?

**b** What is the time period of the signal (the time for one complete cycle)?

**c** What is the frequency of the signal?



More questions on the CD ROM

Examination questions are on page 156.