Or how an antenna emits radio energy! If a pair of conductors are connected at one end to a high frequency oscillator (which is producing AC voltages at a frequency in the Mhz range),and at the open end is spread out to form an antenna, we have a simple transmitter (as shown in Fig. 1a). As the electrons surge back and forth in the alternating current, there are changes in the electric field E associated with the charges, and changes in the magnetic induction B associated with the current. The electric field and magnetic field lines are thrust out into space, and their rapid variations lead to the radiation of electromagnetic waves.

It is an experimental fact that changes in electric and magnetic fields travel outward with the speed of light. Suppose that you waved an electrically charged rod back and forth, and an imaginary observer, equipped with the proper instruments, enabling him to detect field strength changes, was positioned a considerable distance from the charged rod and he attempted to observe any changes in the local fields due to the waving of the rod. He would not "know" that the rod had moved until after a time interval given by the distance from the rod to his instruments, divided by the speed of light. (Fig 1b.). Since light travels very fast this is a small time delay and often need not be taken into consideration.

But in considering how electromagnetic waves are formed, the delay is extremely important. Changes in electric and magnetic fields at considerable distances from their "sources" do not occur at the same instant as the changes at the source, but are delayed or retarded because the changes travel with the finite speed of light.

The two vertical conductors connected to the high-frequency oscillator constitute a dipole antenna (Fig. 1a). We can think of the antenna as having charges on it that move with simple harmonic motion, in other words, charges that accelerate. Such an antenna will radiate electromagnetic waves. To see how this occurs, let us consider two regions, one quite near the antenna and one at some distance from the antenna.

Near the antenna the electric and magnetic lines build up and collapse in step with the charge and the current respectively on the two halves of the antenna. Look at Fig. 2, When the upper half of the antenna is negatively charged, electric lines run to it from the lower half (Fig. 2 a-c). The electric field builds up and collapses in phase with the charge on the two halves of the antenna When the charge is zero, the electric field disappears (Fig. 2 d). Likewise, the magnetic lines circle the antenna in the direction determined by the current and the left-hand rule.

When the current is zero, the magnetic field disappears (Fig. 1b, b and f). Since the current and the charge are 90 out of phase with each other (the current has to precede the charge so that the charge can accumulate) the electric field and the magnetic field near the antenna are 90 out of phase, (this is the induction field).

Lets consider what happens now to the electric field at a considerable distance (like Moncton), from the antenna. In this case the time delays are very important. Although we shall limit attention to what is happening to the electric field, comparable changes are taking place in the magnetic field. As the charge builds up on the antenna, the electric field lines spread out into space but are still anchored at their ends to the antenna charges (Fig. 3). Notice , that the lines far from the antenna fall out of step with what is happening near the antenna. (compare Fig 3 with Fig. 2). In Fig. 3e, for example, the electric lines near the antenna have reversed their direction, but the lines far out have not responded yet. In Fig. 3-f, there are electric lines in both directions. In this region, electric field lines break away from the antenna and form loops that spread out through space* (Fig. 4). These loops, several of which are shown in Fig. 4, are the electric field component of the electromagnetic wave. An electric fluxmeter placed at "O" (Fig. 4) would register successively an increasing electric field strength, a zero field strength, and then a increasing field strength in the downward direction as the loops passed by. This is the sine-wave variation noted in Fig. 5.

We have not shown the magnetic-field component to avoid complicating the illustration but loops of magnetic-field lines form in a similar way at right angles to the electric field, completing the electromagnetic wave. ***E*** and ***H*** in the electromagnetic wave are in phase with each other. They are no longer 90 out of phase as they were in the region near the antenna (this is the radiation field).

Once the electromagnetic wave is formed, it has an independent existence. It now no longer depends upon the antenna. The moving electric field creates the "displacement current" which is responsible for the induction in space, field (***H*** field). Thus, the changes in ***E*** and ***H*** are self-supporting. The wave travels through space with the speed of light, carrying energy with it. The wave spreads out as it goes, and there is a decrease in the energy carried per unit area of the front of the wave. Note that in Fig. 4, the concentration of the wave is greatest in the direction at right angles to the dipole antenna and practically zero in a direction in line with the antenna. Other concentrations of radiated energy can be achieved by using reflectors behind the antenna or by using many antennas radiating in phase with each other. The energy radiated per unit time by an antenna depends upon f to the fourth power, the frequency raised to the fourth power. If the frequency is doubled, the power radiated increases sixteen-fold. (with respect to using the same antenna).

It also should be remembered that as the wave travels, every electron or molecule that it comes in contact with or cuts across, some of its energy is left behind. A large portion is used in the process of refraction or reflection from the ionosphere.