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CHAPTER I

INTRODUCTION

THE general principles on which a message is sent from one place to another by means of Wireless Telegraphy are in many ways analogous to the principles involved in sending a sound signal from one point to another. In the latter case the transmitting instrument, consisting of a bell or syren for instance, is made to set the air surrounding it into a state of rapid vibration. These vibrations spread themselves in all directions in the form of sound waves in the air, and impinging on the receiving instrument, usually the human ear, give rise to effects which enable the sounds to be recognised.

In a Wireless Telegraphy Installation a similar process is taking place during the sending of a message. Corresponding to the mechanical vibrations of the bell or syren are the electrical oscillations in the aerial at the transmitting station, whose function it is to set the aether surrounding it into a state of violent electrical vibration. These electrical vibrations in the form of electromagnetic waves in

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the aether are transmitted in all directions and impinging on the receiving aerial, can be recognised by means of the receiving instruments.

The apparatus required at the transmitting station to set up these vibrations, and at the receiving stations to recognise them, is, however, rather more complicated than that required to give rise to and recognise the sound waves, when signalling by that means; and consequently before describing these instruments it is proposed to give a brief account of the electrical phenomena upon which their action depends.

The most familiar idea of electricity is the Current of Electricity, generally regarded as the flow of a kind of intangible fluid whose behaviour is similar to the flow of a stream of water along a pipe. Electricity, looked upon in this way, will flow freely through some materials, the most important of which is copper, which are known as "Conductors" of electricity; but only with extreme difficulty through others which are called "Non-conductors" or "Insulators." Well-known materials of the latter kind are air, glass, mica, ebonite, etc. A long copper wire forms a path for electricity to flow along just as the inside of a water-pipe forms a space along which a stream of water can flow. The quantity of electricity passing a point in the wire in, say, a second is analogous to the quantity of water passing a point

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in the pipe in a second. When a large quantity of electricity passes in a second the current is spoken of as being a large one, and *vice versa*. If the wire along which such a current of electricity is flowing is broken the current will cease because at the break a non-conducting barrier has been introduced. This is equivalent to putting a valve into a water pipe and closing it, or to blocking up the pipe with some impermeable material.

To force water along a horizontal pipe there must be a difference of pressure between the two ends, which must be maintained if the stream is to continue. Similarly in the electrical case, there must be a difference of electrical pressure to cause electricity to flow from one end of a wire to the other, which must be maintained if the current is to continue. It may be pointed out that this electrical pressure is not of the same mechanical nature as the pressure in the water-pipe. It cannot be measured in pounds per square inch or tons per square foot; but it is nevertheless closely analogous to it. Electricity cannot flow without a difference of electrical pressure, but a difference of pressure can exist without a current if there is no conducting path for the electricity to flow along. Electrical pressure is often called Electromotive Force.

If water is supplied from a pressure main to a water motor through a small pipe a large proportion

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of the pressure is lost and only the remainder is available for working the motor. This is bad engineering as the water is wasting its energy in the pipe in overcoming friction instead of doing useful work in the motor. To prevent this wastage a larger pipe must be used. A similar thing occurs in the electrical case. If a current of electricity is sent along a small wire it wastes its energy, and to prevent this wastage a thick wire must be used. The thin wire is spoken of as having a "high resistance" and the thick one as having a "low resistance." For wireless purposes it is highly undesirable for the current to waste its energy in this way, and so all circuits should be of low resistance, i.e. of large sized copper wire, and where the currents are very large, large copper tubes must be used. Copper is used because size for size the wastage is less with copper than with any other practicable material.

Electricity can under some circumstances be forced through a non-conducting break in a circuit. This occurs with a high electrical pressure and is of the nature of a disruptive spark bursting through the insulating medium. After the initial spark has formed the path through the insulator becomes momentarily a fairly good conductor of comparatively low resistance on account of the volatilisation of the materials. In many of the transmitting instruments used for wireless telegraphy a spark of this kind is continually taking

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place between two conductors separated by a layer of air. This point at which the sparks are formed is generally known as the "spark gap." With air as the insulating medium which is burst through, the non-conducting state quickly restores itself when the current ceases and the same high electrical pressure will be necessary to produce another spark.

A stream of water may flow in many ways. For instance it may flow steadily in one direction at a uniform rate. If a tap, connected to a constant pressure main, is left turned on this steady flow will take place. Again it may flow backwards and forwards, first in one direction and then in the other as is approximately the case at the mouth of a tidal harbour. Corresponding to these two ways there are two ways in which electricity can flow. It can flow steadily in one direction, in which case it is known as a Direct or Continuous Current. Or again it can flow alternately in one direction and then in the other, when it is known as an Alternating Current. The variations of an alternating current repeat themselves regularly after certain intervals. Starting from an instant at which the current is zero, as at 0, fig. 1, the changes are as follows: at first the current increases to a maximum value at *A* and then dies to zero again at *B*. During this time the electricity has been flowing in one direction only, but beyond *B* the flow is in the opposite direction, the current being a

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maximum at *C* and falling to zero again at *D*. This series of changes is what is termed a "complete cycle." The two halves of the cycle occupy the same time and at corresponding instants the currents are equal but of course in opposite directions. The "frequency" of an alternating current is the number of cycles passed through per second.

As well as these two there is a third important way in which a current of electricity may vary, which

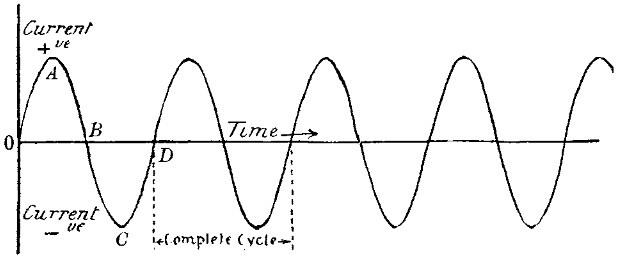

Fig. 1. Diagram of Alternating Current

is confined almost entirely to wireless work. It may flow in groups of oscillations to and fro, the amplitude of the oscillations of each group gradually decreasing and the intervals between the beginning of each group and the next being generally large enough for the oscillations to die down entirely in the meantime. Such currents are known as Oscillatory Currents. As an analogy, suppose a U-tube having arms about a yard in length to be filled with water to within about

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a foot of the top. Under normal conditions the level of the water would be the same in each arm, but it could be made different by, say, blowing down one of them. Let the two levels be made different in this or some other way and let the constraint be suddenly removed. The levels immediately tend to readjust themselves and if the bore of the tube is not too small there will be several oscillations up and down before the water finally comes to rest. Suppose the disturbances of the level to be repeated at regular intervals, generally greater than those required for the water to settle down, and the resulting motion of the water is analogous to the oscillatory currents. Each group of oscillations is called a "Train" of oscillations and may consist of one or two only or of a large number of them. The term "cycle" is used with oscillatory currents to denote two consecutive surges to and fro. These are almost similar to a cycle of an alternating current, the only difference being that with the oscillatory current the amplitudes of consecutive half cycles are steadily diminishing instead of remaining constant as with the alternating currents. Fig. 2 is a diagram of an oscillatory current. The term "frequency" is used with oscillatory currents in practically the same sense as with alternating currents. It is the number of cycles which would take place in a second *if the train continued uninterruptedly for that time.* In practice the trains

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do not last as long as this and there is usually a period of quiescence between them. The actual number of cycles passed through in a second is therefore less than the frequency. For suppose that in a given case there are 100 trains per second each lasting for one-thousandth of a second and consisting of 50 cycles. The actual number of cycles passed through in a second will then be $100 \times 50 = 5000$. But if one train had lasted uninterruptedly for a whole

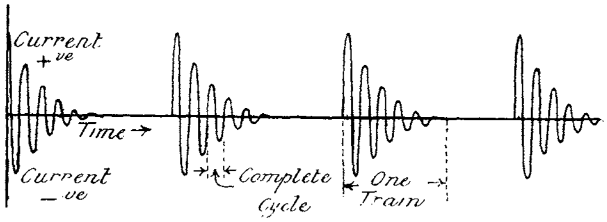

Fig. 2. Diagram of Oscillatory Current

second the number of cycles passed through would have been $50 \times 1000 = 50{,}000$. This latter, and not the former, is the frequency of the oscillatory current in question. It is in fact the rate at which the cycles are being passed through during a train, expressed as so many per second.

The frequencies met with in wireless work are for alternating currents 25 to 1000 cycles per second and for oscillating ones 50,000 to 3,000,000.

Each of these three different types of current

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involves three corresponding electrical pressures or electromotive forces. A direct current will be produced by a steady unidirectional electrical pressure; for an alternating one an alternating electromotive force of the same frequency will be required; and for an oscillating one an oscillating pressure is necessary.

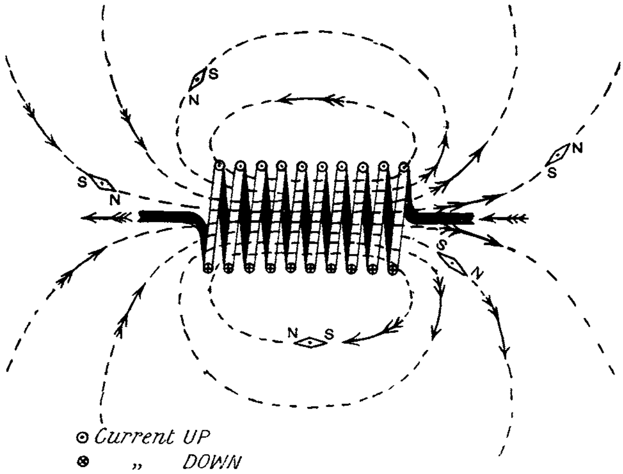

Fig. 3. Magnetic Field near a coil carrying an Electric Current

When a current of electricity flows along a wire it produces magnetic effects in the surrounding air. Suppose for instance that the wire is wound up into the form of a coil as shewn in fig. 3, and that an electric current is sent round it. Then, anywhere in

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the neighbourhood of the coil a freely suspended small magnet will be found to be strongly affected. Instead of pointing N. and S. as it usually does it will be found to set itself in directions indicated by the arrows and lines in the figure. This behaviour of the small magnet shews the presence of what is called a "Magnetic Field" around the coil. This magnetic field depends upon the current for its existence and varies with it.

A current of electricity flowing round a coil has further the important property of being able, under suitable conditions, to give rise to currents in other coils near it to which it is not in any way connected. For instance, consider two coils *A* and *B*, fig. 4, *A* being connected to a battery or other source of current and *B* being quite separate from *A*. Then whenever the current in *A* *is made to change* an electromotive force comes into existence in the coil *B* tending to make a current flow round it. If the two ends of *B* are joined by a conducting wire currents will actually flow round the coils; but if the ends are not joined the electromotive force will be there and there will be no current. This electromotive force in *B* is called an "Induced Electromotive Force," and the current it will give rise to if the ends of the coil are joined together is called an "Induced Current." The induced electromotive force in *B* is brought about by the agency of the magnetic

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