CHAPTER XII

Some Points about Capacity and Inductance

THE main essentials of a wireless installation are capacity and self-induction or inductance; introduced, for a receiving station, into a collector and a detector, and, for an emitting station, into a generator and an emitter. The emitter and the collector are one and the same —the aerial. Transfer from generator to detector is usually effected by a switch. Capacity and self-induction are the essential ingredients of an aerial, and it is on them that the wave-length depends. But it is a question what value the capacity and inductance shall have, and how they shall be arranged.

It is obvious that the more open the capacity, the better will it serve as emitter or collector; hence, whatever capacity is used, it should mainly be in the aerial, for highest efficiency. Any defect of capacity in the aerial can be supplemented by a closed adjustable capacity; which, of course, is very convenient, and will always be subordinately required for tuning.

If the aerial could be arranged so as to extend to a great vertical height, its capacity

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would be as open as possible, and its efficiency as emitter or absorber would be correspondingly high ; for both the radiating and the absorbing power is proportional to the square of the height.

But there are practical limitations to the height convenient, so that when the greatest available height is attained, any bulk of the aerial beyond that is naturally horizontal.

In every ordinary case, however, the figure expressing the electrostatic capacity of an aerial in metres is small. It depends on the length of wire used, but is always incomparably smaller than the length of that wire. Expressed in electrostatic measure, we shall find that for an open vertical wire the capacity is about one-twentieth the length of the wire, and that the capacity of an aerial is seldom more than one-fifteenth or possibly one-twelfth of its length.

The wave-length, however, depends on the capacity and the self-induction, being indeed six times the geometric mean of these two lengths. So, for any considerable wave-length, the length representing electric capacity being small, the length representing magnetic induction must be great.

Hence, to get any reasonable wave-length, the capacity of the aerial must be supplemented,

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or reinforced and made effective, by a considerable amount of self-induction. But whereas the capacity area may with advantage be as extensive as possible, there is no advantage in extending or spreading out the inductance ; on the contrary, there is an advantage in compressing it into small compass, so that quite a minute coil will serve for a great wave-length.

Why should there be this advantage in constricting the self-induction coil ? Because any capacity which it possesses is useless, and, to some extent, deleterious. There is no gain in mixing up capacity and inductance. They should be kept distinct and separate. The upper part of the aerial, combined with the earth below it, should have all the capacity ; and the self-induction coil should have as little as possible. Then the wave-length has a chance of being clear and definite.

Whatever capacity exists between the turns of the coil has the effect of shunting some of the oscillation, and making it useless. The shunted portions would have any number of indefinite frequencies, and would not contribute to the main wave-length.

This has become known to practical men, and, as a result, what is called *basket*-winding has often been adopted, in order that the turns of wire may have some intervening space between them, and so not lie too close together. Of course, this has some effect in diminishing self-induction as well as capacity, since the magnetic influence of the turns of wire on each other is diminished. But the reduction in capacity is found to more than compensate this disadvantage, and it is easy enough to get sufficient self-induction by making the coil bigger.

Only, of course, then more wire has to be used for the coil; and the more wire it contains the more capacity it has. So it is evidently a question of compromise, and the best result has to be found by practice. Some capacity between the turns is inevitable; and, apart from basket-winding, we may consider how best to secure a minimum of it.

First of all, then, thin wire is indicated. From the capacity point of view, the thinner the better. The only disadvantage of thin wire is that its resistance is high. But resistance only affects the damping of the vibrations; and the vibrations are usually sufficiently persistent to cause damping to have no great importance, unless it be excessive. Damping by radiation of energy is inevitable, and moreover useful. Other damping is of no use, but it is usually small in comparison. Of course, the wire must be of the highest conductivity. But, given that, there is a gain in keeping its thickness very small, say even No. 40 S.W.G.

If in any case so much wire has to be used that its resistance does become excessive, then instead of making the wire thicker it would be better to have several wires in parallel, the said wires being very thinly insulated from each other, and then stranded or laid together.

A strand of this kind forms a very perfect conductor for high-frequency oscillations, inasmuch as every part of a thin wire helps to carry the current; whereas only the outside of a thick wire is effectively conductive for an extremely high frequency of oscillation, so that the effective resistance of a thick wire is considerably greater than it would appear to be when measured in the ordinary way with steady currents and a Wheatstone bridge. Such considerations do not apply to a strand of fine wires, however thinly insulated from each other they are.

It may be said, why insulate the parallel wires from each other at all? But it is clear that if they are in metallic communication all along their length, they virtually constitute a thick wire. The ether waves cannot then gain access to more than the combined periphery. The inner wires will be screened by the outer ones, just as the interior of a thick conductor

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is screened. Whereas if there is any insulating material between them, however thin, the ether waves can, as it were, soak in and utilize the conducting power of all the wires. (It must be remembered that it is the ether, and not the copper, which really transmits the energy ; the function of the insulating material is vital.)

Given then as thin a conductor as suffices for the quantity of electricity to be conveyed, the expression for the capacity of such a wire shows that in order to keep it small the turns of wire in a coil had better not lie close together. They can be separated by an air space, or they might be separated by a thick cotton covering outside the real insulation—a covering as airy and uncompact as it can conveniently be made.

However that may be, and however the distance between the wires is secured, it can be allowed for in the calculation ; and the best method of obtaining the separation can be left to instrument makers.

The main consideration is to use as little wire as possible in the self-induction part of an aerial ; or, in other words, to wind the coil so as to get the maximum self-induction out of a given length of wire. This will have a double advantage. It will keep down the resistance, and it will keep down the capacity—both of which must obviously depend on the length of wire used.

So far as I know, insufficient attention has hitherto been paid to this important consideration, and I doubt if coils are often wound so as to obtain the maximum self-induction. I regard this as important, and propose to take if fully into consideration.