CHAPTER XXIII

A Plea for Easy Specification

WHEN working with ordinary coils and condensers in the laboratory, the specification of capacity in microfarads is convenient enough, and so is the specification of inductance in terms of henries or secohms. But when working with wireless, and wave-lengths, it is convenient to have the aerial capacity, and the inductances associated with it, expressed in terms of length; because the geometric mean of those two lengths—that is, the square root of their product—gives the wave-length direct when multiplied by 2π, that is practically, for rough estimate, by 6. Six times the square root of the inductance and capacity multiplied together, is a close approximation to the wave-length: and in predetermining the inductance required for any given case this must surely be a handy rule.

It is well known that capacity in electrostatic measure is a length, and that inductance in electromagnetic measure is also a length. The truth is that in all units—that is to say, in absolute measure—capacity is really K times

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a length, while inductance is μ times a length. And it is natural to express the one in static measure, under the convention that $K = 1$, and the other in kinetic—that is magnetic—measure with the totally different convention that $\mu = 1$. The two conventions are totally different; for the one has to do with charge, and the other with current.

The capacity of an ordinary amateur aerial is some simple fraction of its height or linear dimensions: about one-twentieth of the length of an isolated thin single wire measures its capacity. But the fraction may vary for different aerials from a twentieth to about a twelfth, as will be shown later. A microfarad is far too big a unit for convenience. A millimicrofarad, or even a micromicrofarad, has to be employed: and they are by no means convenient. The length corresponding to a microfarad is 9 kilometres. So a millimicrofarad is 9 metres, and a micromicrofarad, is nine-tenths of a centimetre; that is to say, 10 micromicrofarads equal 9 centimetres. So that for a rough estimate a micromicrofarad may be taken as a centimetre, though it is a trifle smaller.

On the other hand, a henry is 10,000 kilometres. So a millimicrohenry—or what is sometimes called a billihenry—is exactly

1 centimetre. While a microhenry is 10 metres, and a millihenry 10 kilometres.

Conversion from one set of units to another is always a nuisance. But, after all, a henry and its submultiples have no particular meaning which the imagination can seize hold of; whereas the length of a metre or a kilometre is easily imagined. Hence it might be well to have the coils used for wireless thus marked—that is, marked in terms of length—using any unit of length that is handy for the purpose and suitable to the coil. Thus, take an aerial of capacity 1 metre, and put a coil of 10,000 metres inductance in series with it. The geometric mean of the two is 100 metres, and the wave-length therefore 600 metres.

The metre, as a rule, is the most convenient unit of length under the circumstances, since wave-lengths are commonly so specified. But some people prefer to work in centimetres; and it is easy enough to remember that a billihenry is 1 centimetre. The farad is not a convenient unit. It was always much too big; but it can be remembered that a microfarad is equivalent to a length of 9 kilometres. In wireless work it is certainly convenient to express capacity as a length, whether it be agreed to specify inductance also in that way, or not.

It is curious to note that a farad coupled

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to a henry (or, what is more practicable, the thousandth of a farad coupled to a thousand henries) would have a slow oscillation period of six seconds, and so give a quite inappreciable wave 1,800,000 kilometres long. A microfarad connected to a henry of inductance would oscillate a thousand times in six seconds, and so generate a wave 1,800 kilometres long, which would still be feeble. Whereas a microfarad coupled to a microhenry would have a frequency a thousand times as great, and so might give a fairly strong wave of length 1,800 metres: the same wave being also generated by a millimicrofarad coupled to a millihenry; the last being more simply expressed as a 9-metre capacity and a 10,000-metre inductance.

The intensity of radiation increases very fast as the wave is shortened. If other things were equal—which they seldom are—the radiating power from a given stock of energy would increase with the fourth power of the frequency of vibration; so that halving the wave-length would multiply the radiating power sixteen-fold. But short waves have been usually considered less penetrating and less suitable for very long distances. Otherwise, and certainly for all near work, short wave-length or high frequency is an advantage.

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CONCERNING THE SPECIFICATION OF TRANSFORMER AND OTHER COIL WINDINGS

It appears to be customary for instrument makers to specify their transformer and other windings by inscribing on them the resistance. That is probably because the resistance is so easily ascertained and verified. But it is not a good mode of specification, and may lead to misunderstanding. What we want to know about a transformer is the number of turns of wire in both primary and secondary, so as to give the transformer ratio, and so as to enable us to calculate the self-induction of each coil, and the mutual induction between them. These, of course, can be ascertained by experiment, even when the transformer contains iron. But some estimate could be made of them if the number of turns and the other dimensions were known. Resistance gives very little useful information.

The same is true of telephones and galvanometers. These windings too are usually specified by resistance. And there must be a temptation to wind them with badly conducting wire, or even some material not copper, in order to get the high resistance more easily. It ought therefore to be widely known that high resistance is no advantage at all. So far as it goes, it is a defect. Resistance is unavoidable in a coil wound with a great length of fine wire, but nobody wants resistance for its own sake. Resistance is only of value when *heat* is desired, as in a heating coil or a lamp filament. For all ordinary instruments the less the resistance the better. High resistance should only mean that a great number of windings have been crowded into a compact space, and the tacit assumption is that the highest conductivity wire has been used. If not, then a specification in terms of resistance is misleading. Number of turns of wire ought to be recorded on an instrument, because that cannot subsequently be ascertained. Anyone can ascertain the resistance, if they want it, without trouble, by means of a Wheatstone bridge. Either the diameter of the wire or the total length of wire used should also be recorded. Either of these quantities involves the other, if the number of turns and the mean radius of the coil is known.

Resistance is only an easy short-hand method of specification, to discriminate one coil from another, if they have all been made in the best possible way; but without this guarantee the specification of an instrument's "resistance" may be misleading, and might lead a workman

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to imagine that high resistance was a desideratum to be obtained in any manner he chose instead of an unavoidable condition inseparable from the other data and the properties of material.

I believe that wire as thin as No. 45 gauge can be coated with enamel as an initial insulator. If so, such wire or something rather less fragile ought to be very serviceable. And whether that wire should be wound compactly, or how far the turns should be separated from each other—either by air or by other harmless material—is a question of compromise which can be best ascertained by practical experience. If the shortest length of wire is employed, by winding it in the shape to give maximum self-induction, I doubt if it is necessary to separate the turns much ; though, of course, some insulation beyond the enamel is required. For although compact winding will give more capacity, as well as more self-induction, the reduction in the length of wire, due to the adoption of the best shape, will give a diminution of capacity—probably as much diminution as separation of the turns would give, since this would necessarily involve the employment of a greater length of wire. In practice, however, it does appear that there is an advantage in some form of basket or open-winding.