INPUT IMPEDANCE OF HORIZONTAL DIPOLE AERIALS AT LOW HEIGHTS ABOVE THE GROUND

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A knowledge of the performance of aerials whose heights above the ground are only a small fraction of a wavelength is of considerable interest in certain cases. A mathematical analysis of this problem was made by Sommerfeld and Renner in 1942, who obtained first and second approximations to the solution of the problem, enabling the computation to be made of the radiation resistance of an aerial in relation to its free-space value, and of the ratio of the useful energy radiated upwards to the total energy.

These approximations appear to be satisfactory for the types of ground and the frequencies which the authors had in mind (e.g. sea-water and wavelengths longer than 40 m). At higher frequencies, where the ground behaves as a dielectric, however, a serious discrepancy exists between the results calculated from the first and second approximations, particularly at low heights and for grounds having low permittivities, thus raising doubt on the validity of both" approximations. On the other hand, the computed radiation resistance shows an unexpected rise at low heights, theoretically tending to infinity for zero height.

Fig. 1 gives the results of some measurements taken at 50-100 Mc/s on a resonant 0.5 wavelength dipole at low heights above the ground, under different ground conditions, for the purpose of checking the validity of the approximate theoretical results of Sommerfeld and Renner. The rise in resistance at low heights indicated by the theory is clearly seen. Measurements made above conducting mats of different mesh-size indicated that, in agreement with Sommerfeld and Renner, the rise in resistance at low heights is due to an increase in the energy radiated from the aerial downwards into the ground.

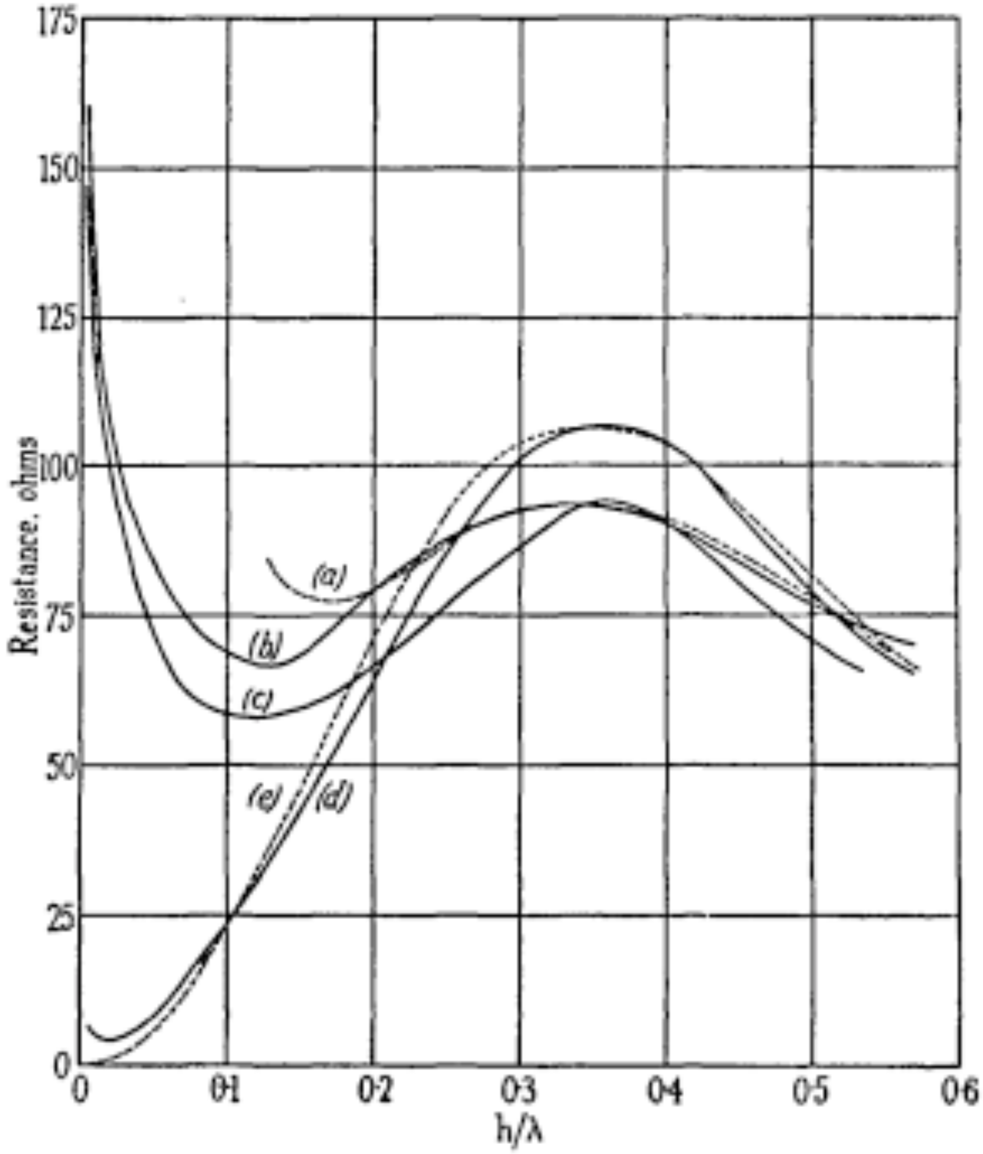

Fig. 1.—Measured input impedance of a resonant half-wave dipole above the ground.

h = height above ground.

(a) Calculated $\kappa = 5$.
(b) Dry ground.
(c) Wet ground.
(d) Conducting mat $a/\lambda = 0{\cdot}0003$.
(e) Calculated $\kappa = \infty$.

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DISCUSSION ON "INPUT IMPEDANCE OF HORIZONTAL DIPOLE AERIALS AT LOW HEIGHTS ABOVE THE GROUND"*

Mr. G. D. Monteath {communicated)'. The author notes a discrepancy between the experimental and theoretical results for low dipole heights. Over dry ground the experimentally determined resistance [curve (b) in Fig. 2] is less than the theoretical resistance [curve (a) in Fig. 2] for heights below 0.2 WL. The discrepancy may be due to the fact that Sommerfield and Renner considered a Hertzian dipole of infinitesimal length, while the experiments were carried out with a half-wave dipole.

At sufficiently great heights the small change in impedance due to the presence of the ground may be regarded as being caused by the reaction upon the dipole of a wave reflected by the ground at normal incidence. Thus if R is the free-space resistance and (R + AR) is the resistance in the presence of the ground, the quantity AR/R will vary with height in a similar manner for either length of dipole. It will, however, be greater by a factor of 1 • 1 in the case of a half-wave dipole, owing to slightly greater directivity.

At very low heights, the effect of the ground on the impedance will be governed mainly by the electrostatic and induction fields, which predominate at short distances, and these differ considerably in the two cases. In general, the near fields of a Hertzian dipole are greater than those of a half-wave dipole giving the same distant field. It is not therefore surprising to find that the loss in efficiency due to ground losses (observed as an increase in resistance) is less serious in the case of the half-wave dipole.

Mr. R. F. Proctor (in reply): The discrepancy between the measured curve for dry ground and the calculated curve for K = 5, at low dipole heights, is most probably due to the approximations which Sommerfeld and Renner have been forced to make in order to evaluate their integral. These approximations appear to be reasonably satisfactory for large values of permittivity and dipole heights, judging from the closeness of the resistance curves calculated by means of the first and second approximations. There are, however, quite large discrepancies between the curves at low heights, calculated from Sommerfeld and Renner's first and second approximations for pure dielectric grounds having permittivities of the order of 5. These differences throw considerable doubt on the accuracy of the second approximation, which still involves serious approximations in its derivation under the above conditions.

A further possible cause for the discrepancy between the calculated and measured curves, at low heights, may be that Sommerfeld and Renner's theoretical curve is based, essentially, on the power radiated from an infinitesimal doublet. To obtain a direct comparison with the radiation resistance of a half-wave dipole, Sommerfeld and Renner apply a multiplying factor to their results for the infinitesimal doublet which is independent of the height above the ground. It is very likely, however, that this factor will be modified, at low heights, owing to the close proximity of the dielectric ground.

It is considered that the local electrostatic and induction fields cannot make any direct increase in the input resistance of the aerial in the case of a perfect dielectric ground. The dry ground (Fig. 2) should correspond very closely to a pure dielectric at frequencies of 50-100 Mc/s.

• Paper by R. F. PROCTOR (see 1950, 97, Part III, p. 188).