NOTE ON THE RESISTANCE OF RADIOTELEGRAPHIC ANTENNAS

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According to the theory the portion of the resistance of an earthed antenna due to its radiation is

\[ R_r = 160\pi \frac{h^2}{\lambda^2} \]

which is approximately \( h^2 \frac{1600}{\lambda^2} \)

Where \( h \) is the height from the earth to the center of capacity of the antenna and \( \lambda \) the wave length, assuming that the earth below the antenna is a good conductor like salt water. As a matter of fact, in most land stations the effective height is less than the actual height and in many cases not more than one-half of it. In all antennas, however, radiation resistance must, according to the theory, decrease as the wave length increases and in accordance with the square law.

It was first noted by C. Fischer\(^2\) that in certain cases the resistance\(^3\) of antennas increased as the period was increased by introducing inductance. Fischer believed that this indicated an increase of radiation with wave length.

The whole course of the phenomenon has been studied by the United States Naval Radio Laboratory and the results published.\(^4\)

Fig. 1 shows the resistance curve of the antenna used by the naval laboratory at the Bureau of Standards and that of the U. S. S. Maine. The first is typical of a land station with poor ground conditions, the curve falling rapidly as the true radiation resistance drops with increasing wave length and then rising.

\(^3\)Leaving out of account the resistance of the inductance coils.
again in a straight line as the wave length is further increased.
The curve for the Maine shows the same drop at the shorter wave
lengths followed by a rise which is very slight. Fig. 2 shows the
antenna resistance of the high power station at Arlington, Va.,
with the towers grounded. Here there is almost no rise as the
wave length is increased, showing how perfect ground conditions
can be made by the use of an extensive network of ground wires.

Up to the present there has been no satisfactory explanation
of the rise of the antenna resistance curve, although it seems cer-
tain that it has something to do with the ground. Experiments
by H. True 5 show, however, that the ground resistance, as indi-
cated by fall of potential methods, is greater at short than at long
wave lengths. If, however, we consider the ground as a dielectric
rather than as a conductor and consider it as a portion of the
total dielectric lying between the antenna, regarded as the upper
plate of a condenser, and the ground water, regarded as the lower
plate, we reach a very probable explanation of the peculiar form
of many antenna resistance curves. For it is well known that the
equivalent resistance of an imperfect dielectric increases as the
wave length is increased.

As an example 6 of experiments showing this, the equivalent
resistance of a certain glass condenser of approximately 0.002 mf
capacity measured in the Naval Radio Laboratory is shown in
Fig. 3. The equivalent resistance of the condenser at the various
wave lengths is determined by placing it in a circuit acted upon
by a buzzer-excited wave meter. The current in the circuit con-
taining the condenser is measured by means of a thermoelement.
The condenser under test is then replaced by a variable air con-
denser adjusted to the same capacity in series with which resist-
ance is introduced until the thermoelement indicates the same
high frequency current as in the case of the glass condenser.
The series resistance then represents the equivalent resistance of
the glass condenser. Fig. 3 shows that the equivalent resistance
of the glass condenser increases in direct proportion to the wave
length, just as does the resistance of the antenna at the Bureau
of Standards beyond 1500 meters.

5 Jahrbuch d. drahtlosen Telegraphie, V, p. 135, 1911.
Fig. 1.—Antenna resistance, Naval Radio Laboratory, U. S. S. "Maine"

Fig. 2
The rise in the resistance curve of the Maine, as shown in Fig. 1, is probably due to the fact that the measurements were made with the ship in dock, as it is impossible to use sufficiently sensitive galvanometers under other circumstances. With the ship in dock, of course, a considerable portion of the field passes through poor dielectric material before reaching the water.

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