AIRCRAFT ANTENNA

Pratt & Whitney-powered Vought seaplane designed for use as a scout bomber and normally catapulted from the decks of battleships and cruisers. Characteristics of this particular ship's radio antenna, from cockpit mast to tail-fin, are readily estimated

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THE ACCOMPANYING CHARTS provide a simple means of determining the approximate electrical characteristics of fixed aircraft antennas by measuring their length, making some slight allowance (dictated by experience) for their proximity to the fuselage or for the size of the ship.

Data obtained through the use of the charts facilitates actual measurement of antenna characteristics and is, ordinarily, sufficiently accurate to permit design of dummy antennas needed when bench-testing aircraft radio equipment.

Quarter-Wave Resonance

Chart 1 is used in determining the approximate length of fixed aircraft antenna for quarter-wave resonance. The intersection points of the vertical lines (measured length of antenna) and the horizontal lines (quarter-wave frequency) with the plotted angular lines indicate the quarter-wave resonance frequency for any length between 10 and 100 ft.

The variation of the angular lines on the right of the vertical dotted line (lengths over 45 ft.) depends largely upon the physical size of the airplane as compared to the length of the antenna. The upper dashed line on the right side of the chart is representative of a small airplane and the solid line represents a large airplane.

The variation shown on the left of the vertical dotted line (lengths under 45 ft.) depends largely upon the proximity of short antennas to the metal fuselage of the airplane. The solid line on the left side of the chart is representative of an antenna reasonably distant from the fuselage, such as one running from a wing-tip to the aft portion of the fuselage. The dashed line immediately below the solid line on the left side of the chart represents a short antenna close to the fuselage, such as one run from a short mast near the cockpit directly aft over the fuselage to the fin of the plane.

The following example illustrates the use of Chart 1: Assume a measured length of antenna as 47 ft. From the chart, the quarter-wave resonance frequency is seen to be approximately 5 Mc. If the plane is small, the resonant frequency will be greater than 5 Mc, if large it will be less than 5 Mc.

Inductance, Capacity, Resistance

Chart 2 is used in determining the equivalent electrical components of an antenna at various operating frequencies. In addition to determining such characteristics at the quarter-wave resonance frequency the equivalent capacitive or inductive reactance and radiation resistance at operating frequencies above or below quarter-wave resonance may be readily determined.

As an example, the equivalent electrical components of the 47 ft., 5 Mc quarter-wave antenna discussed above may be determined for an operating frequency of 3 Mc.

The vertical lines marked across the bottom of the chart from 0.1 to 3.0 represent the ratio of the selected operating frequency to quarter-wave resonant frequency, the latter being determined by use of Chart 1, i.e.

$$\frac{\textit{selected operating frequency}}{\textit{quarter-wave resonant frequency}}$$

CHARACTERISTICS

By measuring the length of a fixed aircraft antenna, making some empirical allowance for its proximity to the fuselage or the size of the ship, reactance and radiation resistance may be estimated with sufficient accuracy to permit the design of a dummy antenna

The horizontal lines marked on the right of the chart represent the antenna's reactance in ohms. Those below the center or zero line indicate negative or capacitive reactance (operating frequency less than quarter-wave). Those above the zero line indicate positive or inductive reactance (operating frequency greater than quarter-wave). The common intersection point of the horizontal lines with the dashed reactance curve and the vertical lines indicates the reactance of the antenna at the selected operating frequency.

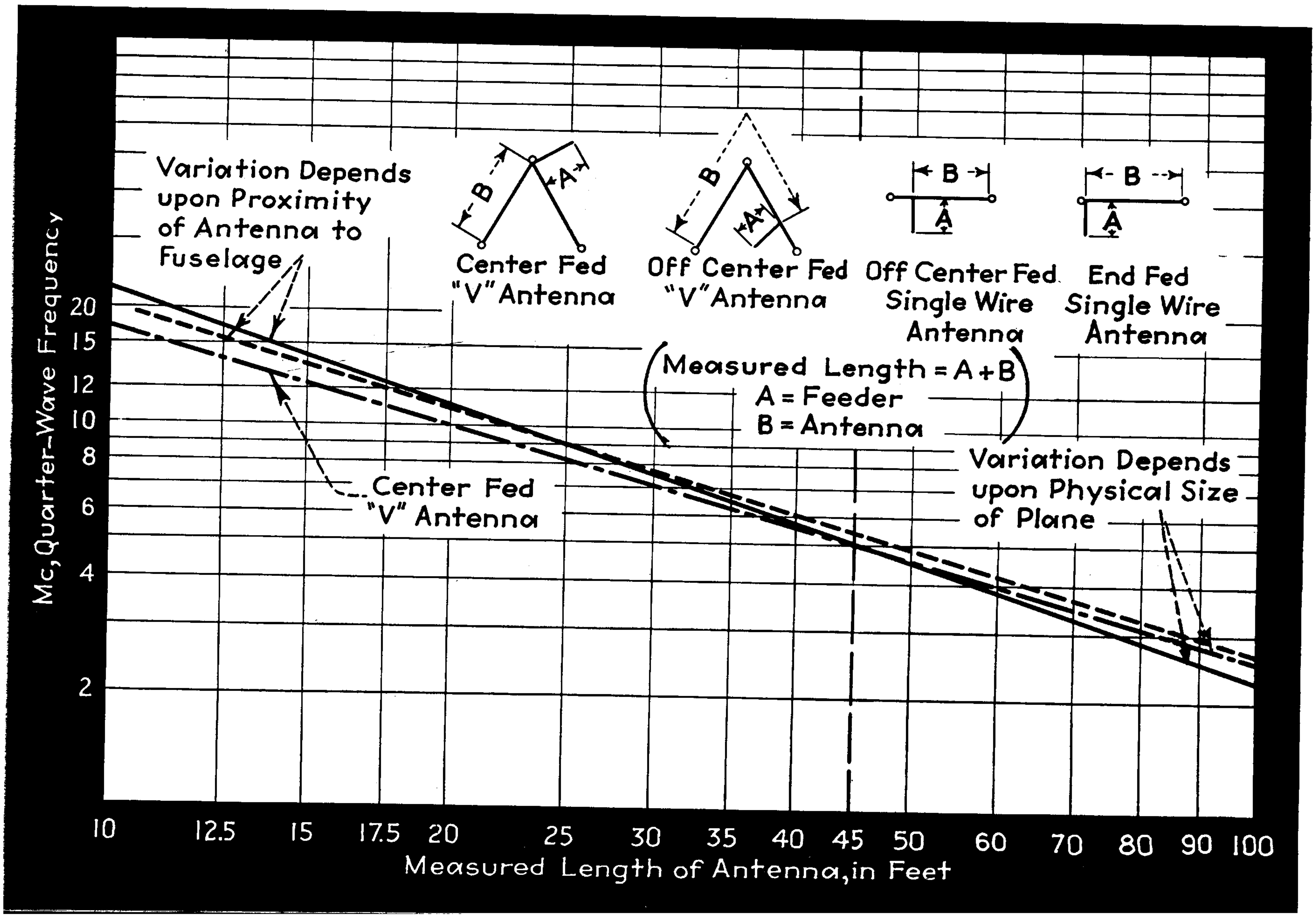
Assume the quarter-wave resonant frequency as 5 Mc (measured length 47 ft.). The reactance of this antenna at an operating frequency of 3 Mc is found as follows: Divide the 3 Mc operating frequency by the 5 Mc quarter-wave resonant frequency. The quotient is seen to be 0.6. Following the vertical 0.6 line to the point where it intersects the dashed rectance curve and then proceeding to the right, the reactance is seen to be about − 325 ohms.

Referring again to the chart, the upper horizontal lines are marked on the left. These numbers at the left represent the radiation resistance in ohms of the antenna. The common intersection point of these horizontal lines with the solid resistance curve and the vertical lines (ratio of operating frequency to quarter-wave resonant frequency) indicates the radiation resistance of the antenna at the particular operating frequency chosen. Thus, the radiation resistance of the 47 ft., 5 Mc quarter-wave antenna at an operating frequency of 3 Mc is seen to be approximately 1.9 ohms as the 0.6 vertical line intersects with the resistance curve and the 1.9 ohm horizontal line as read on the left.

The lower, solid angular lines mark in terms of capacity values which, when multiplied by a factor shown on the chart, produce a capacitive reactance equal to that of the antenna. For example, the effective value of capacitance of a 47 ft. 5 Mc quarter-wave antenna at an operating frequency of 3 Mc is found as follows: The vertical 0.6 line intersects the reactance curve at a point just slightly higher than that of the 75 $\mu\mu$f capacity line, indicating a value of capacity greater than 75 $\mu\mu$f or approximately 80 $\mu\mu$f. This value of 80 $\mu\mu$f, when multiplied by the 10Mc/5Mc is 160 $\mu\mu$f, which is the effective capacity of the 5 Mc antenna under discussion when operated at 3 Mc.

The upper, solid angular lines mark in terms of inductance values which, when multiplied by a factor

CHART 1—Approximate lengths of fixed aircraft antennas for quarter-wave resonance are shown graphically. Empirical variations caused by proximity of the antenna to the fuselage and the physical size of the ship are indicated



shown on the chart, produce the equivalent inductance of the antenna at the particular operating frequency chosen. The inductance value is found the same way as capacitance, outlined above, using the angular inductance lines instead of the angular capacitance lines.

(It is important to note when using the chart that the capacitance lines are used only when the antenna has capacitive reactance at the operating frequency, i.e less than quarter-wave frequency. The inductance lines are used only when the antenna is inductive, i.e. greater than quarter-wave frequency.)

Estimating Procedure

To review the examples illustrated, by the use of the antenna charts a 47 ft. aircraft antenna is found to be quarter-wave resonant at a frequency of 5 Mc. At an operating frequency of 3 Mc it is found to have a capacitive reactance of -325 ohms and a radiation resistance of 1.9 ohms. The value of reactance is equivalent to a capacitance of 160 $\mu\mu$f. Thus, a good grade air dielectric capacitor having a capacitance of 160 $\mu\mu$f, in series with a non-inductive resistance of approximately 2.0 ohms would simulate a 47 ft. antenna at a frequency of 3 Mc. This would constitute a suitable dummy antenna for the bench testing of aircraft radio equipment to be installed in an airplane having an antenna 47 ft. long and operated on a frequency of 3 Mc.

The characteristics of an aircraft antenna at various operating frequencies may, then, be readily determined by the following procedure:

(a) Measure the length of the antenna from the antenna insulator on the skin of the fuselage to its farthest point. If the antenna is an off center fed "V", do not include the short side. Measure the length of lead to the "V" plus the length of the longest side of the antenna proper to determine the measured length of the antenna.

(b) From Chart 1, determine the quarter-wave resonant frequency, taking into consideration the size of the airplane if the antenna is long or the proximity of the antenna to the fuselage if the antenna is short.

(c) Determine the ratio of selected operating frequency to the quarter-wave resonant frequency by dividing the operating frequency by the previously noted quarter-wave frequency. This numerical value coincides with the numerical value of one of the vertical lines on Chart 2.

(d) Determine the reactance by the common intersection of the applicable vertical line, the dashed reactance curve and the nearest horizontal line, reading the reactance value on the right side of Chart 2.

(e) Determine the effective capacitance or inductance by multiplying the value of capacitance or inductance found on the solid, angular line intersecting the point on the reactance curve obtained in connection with (d) above, by the factor shown on the chart.

(f) Determine the radiation resistance by the intersection of the vertical line obtained in (c) with the resistance curve and the nearest horizontal line, reading the value on the left.

Both charts were compiled empirically and are the average of the characteristics of a number of antennas of different lengths and types on various types of airplanes.

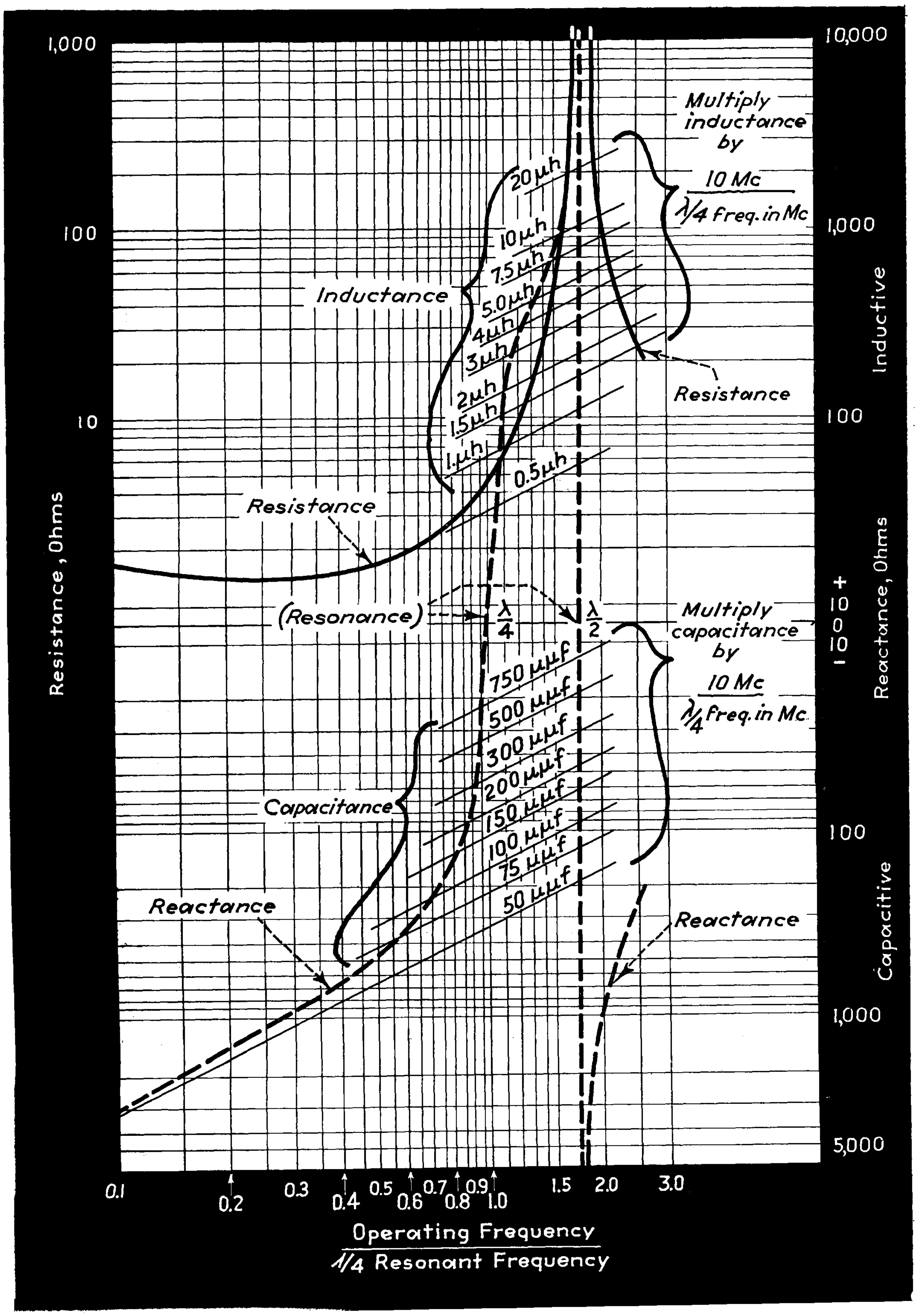


CHART 2— Approximate electrical characteristics of a fixed aircraft antenna operated above or below the quarter-wave resonant frequency may be determined by using the chart as outlined in this text.

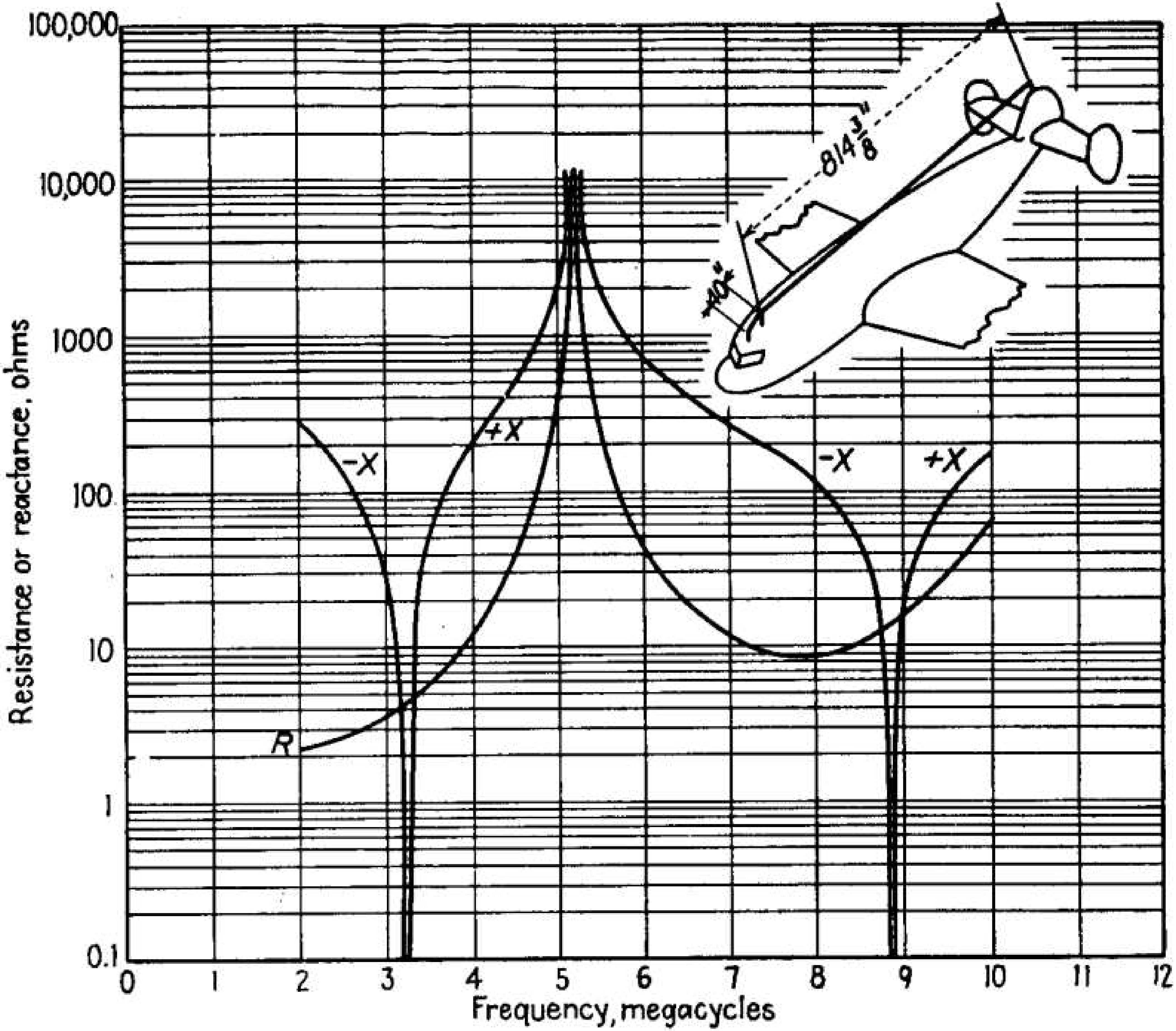


Fig. 172.—Electrical characteristics of transmitting antenna on experimental model of Douglas DC-4 airplane.