SIXTEENTH WEEK. G.B.Todd,RM1c.
ANTENNA CHARACTERISTICS

QUESTION #1. Give a definition of the function of an antenna.

ANSWER #1. The function of an antenna is to radiate energy in the form of electro-magnetic or Hertzian waves for purposes of transmitting. These emitted waves may successively reach the same amplitude in which case they are saiddto be undamped or may be emitted in trains of waves each oscillation of which reaches an amplitude slightly less than that of the preceding oscillation in which case they are said to be damped. The function of an antenna for receiving purposes is to collect part of the energy emitted from a distant transmitter so that it may be used to cause signal responses in the receiver. The antenna essentially is an elevated structure which is insulated from the ground. It contains inductance, capacity, and resistance and is therefore oscillatory. Its electrical period may be changed by inserting inductance or capacity in the circuit in order to conform with requirements or to make it resonant.with the frequency of the distant transmitter.

QUESTION #2. With a known inductance and capacitance setting at resonance, show formula for finding the frequency.

ANSWER #2. Formula:

$$f = \frac{1000}{2 \text{ pi} \sqrt{LC}}$$

Where: f = frequency in cycles.
L = inductance in microhenries.
C = capacity in microfarads.

QUESTION #3. When the inductance and capacitance are known, how may the natural wavelength be computed?

ANSWER #3. Formula:

$$\text{Wavelength} = 1885 \sqrt{LC}$$

Where: Wavelength expressed in meters.
L = inductance in microhenries.
C = capacity in microfarads.

Wavelength or frequency may also be found directly from Table #13 in Robison's Manul, if the product of the inductance and capacitance are known.

QUESTION #4. By increasing the product of the inductance and the capacitance four times, what effect will it have on the wavelength?

ANSWER #4. By increasing the product of the inductance and the capacitance four times the wave length will be approximately doubled.

QUESTION #5. What is the natural wavelength of an antenna containing a capacity of zero point zero zero one MFD and an inductance of 454 MH.

ANSWER #5.

$$LC = .001 \times 454$$

$$LC = .454$$

$$\text{Wavelength} = 1885\sqrt{.454} = 1269.4 \text{ meters. Ans.}$$

It would be shorter to ascertain the wavelength directly from the tables.

QUESTION #6. What capacitance must be combined with an inductance of 880 microhenries in order to tune a circuit to 3500 meters?

ANSWER #6. Formula:

$$C = \frac{\text{Wavelength}^2}{1885^2 \times L}$$

Substituting:

$$C = \frac{3500^2}{1885^2 \times 880}$$

$$C = \frac{\overset{49}{\cancel{245}}\;\cancel{12250000}}{\underset{71}{\cancel{3550000}} \times \underset{176}{\cancel{880}}} = \frac{49}{12696}$$

$$C = 0.003922 \text{ microfarads. Ans.}$$

QUESTION #7. A condenser has a capacity of 0.004 microfarads. What inductance must be placed in series with this condenser to obtain a wavelength of 600 meters?

ANSWER #7. Formula:

$$L = \frac{\text{Wavelength}^2}{1885^2 \times C}$$

$$L = \frac{600^2}{1885^2 \times .004}$$

$$L = \frac{\overset{\cancel{9000}\ 1800}{\cancel{360000}}}{\underset{71}{\cancel{3550000}} \times \cancel{.004}} = \frac{1800}{71}$$

$$L = 25.35 \text{ Microhenries. Ans.}$$

QUESTION #8. An antenna 40 meters high (130 feet) radiates a wavelength of 600 meters. Radiation is 10 amperes. What energy is emitted or thrown off from the antenna? Show formula.

ANSWER #8. Formula:

$$P = \frac{1580 \times I^2 \times h^2}{\text{Wavelength}^2}$$

Substituting:

$$P = \frac{1580 \times 10^2 \times 40^2}{600^2}$$

$$P = \frac{1580 \times 1\cancel{00} \times \overset{4}{\cancel{1600}}}{\underset{9}{\cancel{360000}}} = \frac{6320}{9}$$

$$P = 702.2 \text{ watts. Ans.}$$

QUESTION #9. A four wire inverted L type antenna 100 feet in length and sixty feet high has a capacity of 0.0004 MFD and inductance of 62,000 centimeters. What is the wavelength. Show formula.

ANSWER #9. 62,000 centimeters equals 62 MH inductance. LC values is equal to 62 x .0004 = 0.0248

$$\text{Wavelength} = 1885\sqrt{0.0248}$$

$$\text{Wavelength} = 1885 \times 0.157$$

$$\text{Wavelength} = 295.788 \text{ meters. Ans.}$$

QUESTION #10. The T type antenna with dimensions as above has a capacity of .0004 MFDS but the inductance is 37,000 centimeters. What is the fundamental wavelength. Show formula.

ANSWER #10. 37,000 centimeters equals 37 MH inductance. LC values is equal to 37 x .0004 = 0.0148

$$\text{Wavelength} = 1885\sqrt{0.0148}$$

$$\text{Wavelength} = 1885 \times 0.1216$$

$$\text{Wavelength} = 229 \text{ meters. Ans.}$$

Practically it would be impossible to change from an L type to a T type antenna preserving the same dimensions without changing the capacity of the antenna.

QUESTION #11. What is meant by an antenna loaded and unloaded?

ANSWER #11. An unloaded antenna is an antenna system containing uniform distribution of inductance, its capacity may or may not be uniformly distributed. Its fundamental period is solely dependent on the distributed capacity and inductance. The loaded antenna is one in which either an inductance or capacity has been inserted in the lead-in. If an inductance has been inserted, the fundamental frequency will be lower; if the capacity has been inserted the fundamental frequency will be increased.

QUESTION #12. What is the general rule for loading the antenna?

ANSWER #12. The general rule for loading the antenna is that when a series capacity is added, the wave length will be decreased and the frequency decreased, the limit being when one half the fundamental wavelength is reached. On adding inductance, the wavelength will be increased and the frequency decreased. If the inductance is increased four times the wavelength will be doubled.

QUESTION #13. What does this effect in overloading, have upon the characteristics of the antenna?

ANSWER #13. The resonant frequency of the loaded antenna will depend on its LC value. Voltages and currents will not have their nodes and loops distributed the same as when the antenna is unloaded. The antenna will radiate at a new frequency depending on the value of the inserted capacity or inductance, but will not be as efficient as when working at its fundamental value. Due to the fact that there are losses present, in all condensers and in all inductances, energy dissipation will take place in the inductance or the capacity which is used to load the antenna. Insofar as little or no propagation takes place from the resultant field of the inductance or capacity, the enrgy dissipated represents loss. Energy is expended without radiation.

QUESTION #14. Explain briefly what takes place in a loop antenna when it is in the path of vibrations of a transmitter.

ANSWER #14. If the plane of the loop is at right angles to the direction of the oncoming vibrations and equal emf will be induced in each side of the loop - the two emfs being 180 degrees different in phase relation. When the current is flowing in a certain direction, in one side of the loop, it will flow with equal intensity in the opposite direction on the other side of the loop. Consequently the emfs will cancel each other and no current will flow. If the plane of the loop lies in the same direction of the oncoming vibrations an emf will be induced in the loop because the magnetic field which is always at right angles to the direction of propagation will thread the turns of the loop and an emf will be produced. (Lenz's Law).

QUESTION #15. Give six general losses that occur in an antenna with reasons and remedies.

ANSWER #15. Six general losses that occur in an antenna are: 1. Absorption losses. 2. Leakage losses. 3. Dielectric losses. 4. Corona losses. 5. Resistance losses. 6. Propagation or radiation losses.

All of these losses are detrimental except the last named loss and should be reduced to a minimum as far as possible. Absorption losses are due to conducting materials being in close proximity to the antenna system. Energy is absorbed from the antenna by induction. The remedy is to place the antenna and lead-in as far from all conducting mediums as possible and to insert insulators at regular intervals in guy wires. Leakage losses are due to imperfect insulaton A high voltage is always present at the extremities of the antenna system and if the insulator at this point is poor, a leakage to ground will take place. The obvious remedy is to use high grade insulators. such as pyrex or porcelain and to avoid the use of electrose or composition insulators. Dielectric

ANSWER #15. Continued.

losses are cuased by the presence of materials in the electro-static field which have low dielectric efficiency. The remedy is to install the antenna in a position so that materials of low dielectric efficiency will not come between it and the ground. Corona losses are cuased by a partial ionization of the air at the extremeties of the antenna system where the voltage is highest. Ionization occurs most easily about a sharp point, consequently the remedy for corona losses is to use corona shields about the insulators. Resistance losses are due to the resistance of the antenna itself, also to the skin effect, which is present at radio frequency. Resistance due to skin effect is usually greater than the copper resistance and becomes more pronounced at the higher frequencies. The remedy is to use conductors of large surface area in the construction of the antenna system. Radiation losses are due to radiation resistance. As the purpose of the antenna is to radiate, and the power radiated is the product of the square of the resistance, the higher the resistance the more power radiated. Radiation resistance increases as the frequency increases and radiation resistance should be maintained as high as possible.

QUESTION #16. Where is the greatest loss in the antenna system aboard ship?

ANSWER #16. The greatest loss in the antenna system and hence in the loss of radiated energy from the antenna system occurs from having the antenna trunk system too closely placed to the lead-in. This loss occurs mostly in the lead-in. This is an absorption loss.

QUESTION #17. How do eddy currents affect an antenna? How can they be paritally avoided?

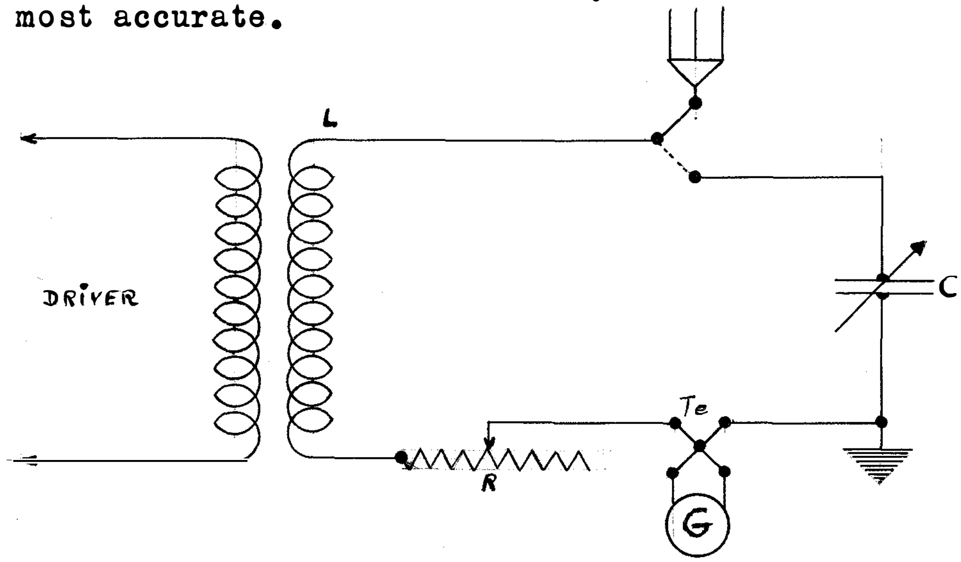
ANSWER #17. Eddy currents reduce the radiation resistance and cause correspondingly greater currents to flow in the antenna system. The power actually used in the propagation is therefore reduced as the radiation resistance is reduced. Eddy currents also cause the tuning to be broad and encourage the production of harmonics. They can be partially avoided by segmenting nearby conductors with insulators.

QUESTION #18. What other effect does losses due to insulators have on the antenna system besides a decrease incurrent?

ANSWER #18. When losses take place due to insulator leakage electro-magnetic waves are generated which tend to neutralize those being radiated by the antenna. This leakage also broadens the resonant peak of the antenna causing a high logarithmic decrement.

QUESTION #19. Show by diagram the substitution method or laboratory method of measuring resistance of an antenna. Which method is the most accurate? When using laboratory method, how many readings are taken?

ANSWER #19. There are three methods of measuring antenna resistance: 1. Resistance substition. 2. Resistance variation. 3. Reactance variation. The resistance substitution method is the laboratory method and is the most accurate.



With the antenna connected to Coil L and the value of R zero, tune the driver to resonance which will be indicated by maximum deflection on the RF meter. Leaving the driver set as before, vary the value of R until the current indication is one half the former value when the value of R is equal to the antenna resistance plus the resistance or reactance of Coil L. Leaving the driver as before, disconnect the antenna and connect Coil L to variable condenser C. Adjust C to resonance with the driver with the value of R at zero. Note deflection and vary R until the reading is half its former value when the reactance of C is exactly equal to the reactance of L (resonant frequency) and the reactance of either therefore is equal to R. The reactance of L was common to both measurements so the actual antenna resistance is equal to the difference in values between the resistance of the antenna with Coil L and the reactance of C with Coil L. This is the variation method. The laboratory method is to use fixed resistors, noting the change in current and solving by equation. The condenser C should be shielded and the rotor connected to the grounded shield, with only one reading in each case of resistance measurement accuracy can be expected within two percent, while with several measurements with various values of resistance and the average taken, accuracy within one percent may be expected.

QUESTION #20. Show formula for measuring the resistance of an antenna.

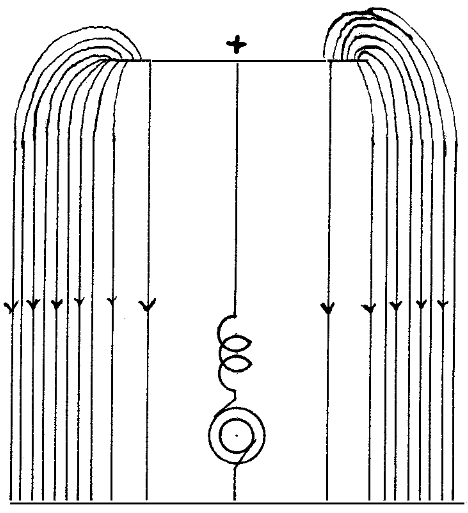
ANSWER #20. $Ra = \dfrac{R^b}{\dfrac{Ia}{Ib} - 1}$ $\quad R^c = \dfrac{Rd}{\dfrac{Ic}{Id} - 1}$ Then $R = Ra - Rc$

ANSWER #20. Continued.

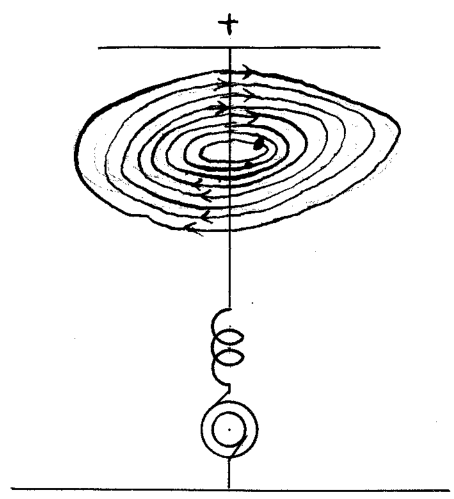
R is actual antenna resistance.
Ra is antenna resistance plus coupling coil reactance
Rb is value of inserted R at second reading taken when measuring the resistance of antenna and coupling coil.
Rc is the reactance of variable condenser C including the reactance of the coupling coil.
Rd is the value of inserted R at second reading taken when measuring the reactance of C and the coupling coil.
Ia is maximum current value at resonance of antenna and driver with the inserted resistance value of zero.
Ib is the current in the antenna circuit after the inserted R is connected for taking the second measurment of antenna current.
Ic is the maximum current in the circuit when C is tuned to resonance with the driver and no inserted resistance is in the circuit.
Id is the current in the circuit when taking the second current reading after inserting R and when measuring the reactance of condenser C along with the coupling coil.

QUESTION #21. Show by diagram how the electro-magnetic and electro-static fields take their positions and directions.

ANSWER #21.

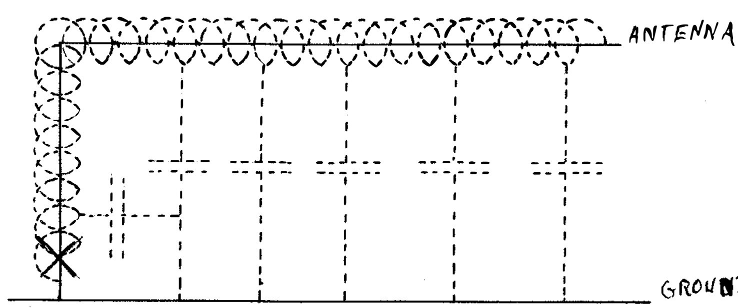


ELECTRO-STATIC FIELD



ELECTRO-MAGNETIC FIELD

QUESTION #22. Show by diagram the distributed inductance and capacity of an antenna.



QUESTION #23. A coil which is shunted with a condenser having a maximum capacity of .0005 MFD tunes to a wave length of 200 meters when the condenser is at maximum value. What is the inductance in microhenries?

ANSWER #23. Formula:

$$L = \frac{\text{Wavelength}^2}{1885^2 \times C}$$

Sub:

$$L = \frac{200^2}{1885^2 \times .0005}$$

$$L = \frac{\overset{\cancel{8000}\ 1600}{\cancel{40000}}}{\underset{71}{\cancel{3550000}} \times \cancel{.0005}} = \frac{1600}{71}$$

$$L = 22.535 \text{ Microhenries. Ans.}$$

QUESTION #24. Show by formula how to convert: frequency to cycles; kilocycles to meters; meters to kilocycles.

ANSWER #24. The velocity of wave propagation is equal to approximately three hundred million meters per second regardless of the frequency or the wavelength. The velocity is always the product of the wavelength and the frequency and inversely, the frequency may be found by dividing the velocity by the wavelength and the wavelength may be found by dividing the velocity by the frequency. The frequency is always measured in kilocycles, so to convert frequency to cycles multiply the frequency by 10^3. The short cut in figuring the wavelength or frequency directly in meters or kilocycles, is to use 300,000 as the dividend. Wavelength equals 300,000 divided by the frequency. Frequency equals 300,000 divided by wavelength. Cycles equals kilocycles multiplied by 1000.

QUESTION #25. Explain the object of a counterpiece. How is it constructed? What is the approximate height from the ground? Why is it insulated? What other name is given the counterpiece?

ANSWER #25. In some places it is difficult to obtain a low resistance connection with the ground. This is true especially in localities. having sandy soil or lack of moisture in the soil. When it is difficult to obtain a low resistance ground, a counterpoise is subtituted for the ground connection. Its object is to capacitively couple the antenna system to the ground rather than use a poor direct connection. It is constructed similar to the antenna and is usually placed directly beneath the antenna. It is insulated for the same reason that any condenser is insulated namely to prevent dielectric leakage. A counterpoise is usually placed nine to 15 feet above the earth. It should contain as much or more conducting surface area than the antenna.

ANSWER #25. Continued.

As the counterpose is closer to the ground than the antenna, its capacity will be greater. Counterpoises are very efficient and should be used where it is impossible or impracticable to obtain a good ground connection. It is called the counterpoise or counter poise antenna.

QUESTION #26. If the highest peak of efficiency is to be maintained when using a high frequency receiver and transmitter, why should the use of electrose insulators be avoided?

ANSWER #26. Electrose insulators are made of composition and they absorb moisture readily. The higher the frequency the more pronounced the skin effect and consequently the moisture penetrates the surface of the insulator it renders theinsulator unfit for high frequency work.

QUESTION #27. In a properly constructed transmitting antenna, why do the guy wires contain a number of insulators spaced a few feet apart?

ANSWER #27. Guy wires in the vicinity of the antenna, absorb radiated energy and more energy will be absorbed as the fundamental period of the guy wires approach the frequency of the antenna. Long guy wires may be in resonance with the antenna or may tune to one of its harmonics. By dividing the guy wires into segments with insulators their resonant frequency is further removed from that of the antenna. Consequently less energy is absorbed and reradiation of harmonics is less pronounced. Eddy currents are induced to a less er extent when guy wires are segmented with insulators.

QUESTION #28. Explain the fundamental basis for propagation of electro-magnetic waves.

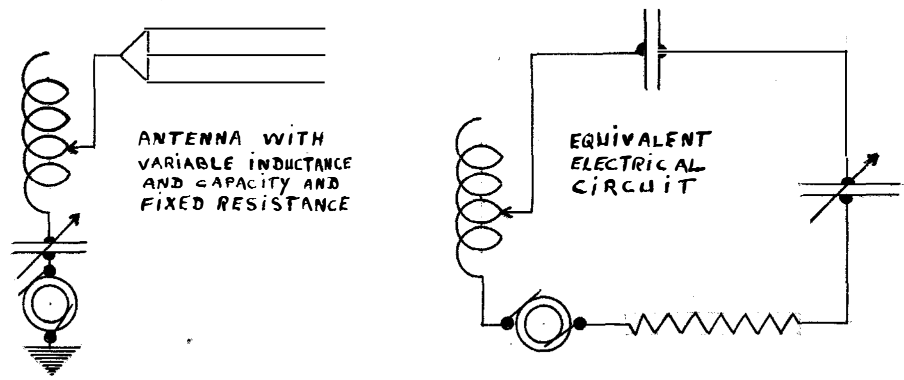
ANSWER #28. The antenna system is equivalent to an inductance a capacitance and resistance in series which form an oscillatory circuit. As the condenser charges and discharges the electricla inertia of its oscillatory circuit, causes the condenser to over discharge to such an extent that it charges in the reverse direction. This swinging back and forth takes place sever al times per second, depending upon the LC value of the circuit. This causes an alternating current to flow. The dielectric strain of the condenser is impressed upon the surrounding ether and due to the al ternate contractions and rarefactions, electro-magnetic waves are propagated from the antenna at an angle depending upon the frequency and upon whether the antenna is being operated on the fundamental or upon one of its harmonic frequencies.

QUESTION #29. Before directional effects are obtained in a flat top antenna, what is the approximate ratio, measuring height to length?

ANSWER #29. Directional effects are obtained in any antenna whose heighth is small compared to its length. In other words in a low long antenna the directional effects are more pronounced in the direction in which the closed end of the antenna points. Theoretically, when the wave front is perpendicular, the antenna will show no directional characteristics, but when the surrounding earth has a poor conductivity, the wave front will be bent and directional properties will exist.

QUESTION #30. Diagram an antenna with variable inductance and capacity, its resistance being fixed and compare it to anequivalent electric circuit.

ANSWER #30.



The antenna is equivalent to one plate of a condenser, the earth representing the other plate. The antenna has an inductance equally distributed along its length which is in series with the inductance of the coupling coil. The variable condenser shown is inseries with the capacity of the antenna and as capacity is cut out of the condenser the total capacity of the antenna system is less. As more turns of the inductance are used the inductance of the circuit is increased. The resonant period at any time is dependent upon the LC value of the circuit.

QUESTION #31. Explain the phenomenon of the radiation field.

ANSWER #31. The circuit contains inductance and capacity and is therefore oscillatory as explained before. As long a the circuit is supplied with enough energy to make up for that dissipated by I^2R losses the circuit will oscillate as oscillations take place and the antenna is alternately charged possitively and negatively a torque is placed on the surrounding ether and as the ether is supposed to b e a very elastic medium, the torque is evidently at long distances from the antenna. The strain travels through the ether with a definite wave form the length of which is dependent upon the Lc value of the oscillatory circuit. The waves travel through the ether in a series of closes loops which move in a direction at right angles to the direction of wave motion.