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FOLDED MONOPOLE ANTENNA

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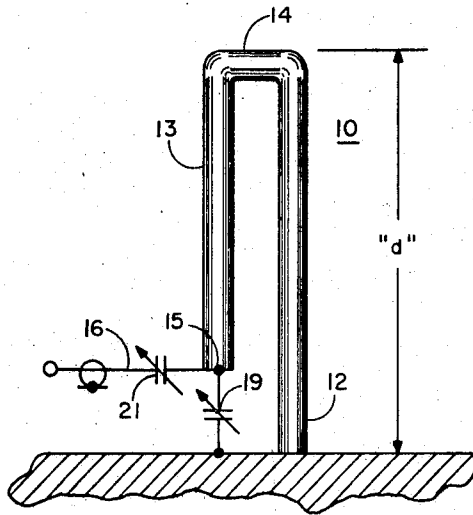


Fig. 1

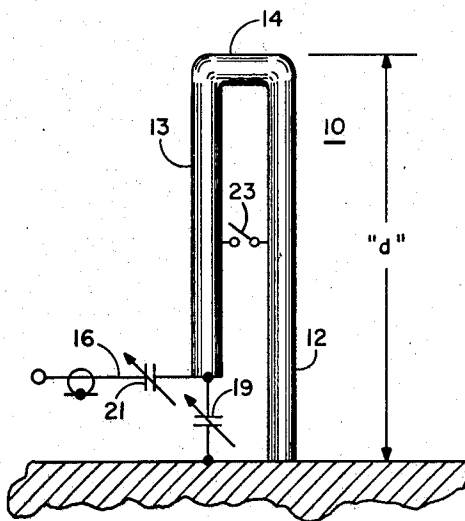


Fig. 2

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FOLDED MONOPOLE ANTENNA

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4 Claims

ABSTRACT OF THE DISCLOSURE

A folded monopole antenna is described. The antenna includes a grounded leg and an ungrounded leg. A feed point is provided at the free end of the ungrounded leg. Both legs have substantially the same height, at least $\frac{1}{36}$ of a wavelength of the operating frequency. The antenna is made of pipe of such material and diameter that its radiation resistance will be of a substantial quantity when the height is greater than $\frac{1}{36}$ of the wavelength. The antenna is matched by a matching network, including a shunt capacitor connected from the feed point to ground and a series capacitor. Capacitors alone may be used when the reactance presented by the antenna at the feed point is entirely inductive.

The present invention relates to transmitting and receiving antenna systems and more particularly the invention relates to a folded monopole antenna system.

Folded monopole antennae are especially useful where the wavelength of waves emitted or received are short and where a rugged antenna design is also required, for example, in fixed positions such as hardened missile sites and in mobile vehicles such as aircraft and submarines.

One conventional folded monopole antenna in use comprises a U-shaped member having a grounded arm and another arm fed by a transmission line. Heretofore it has been assumed that the operation of such an antenna is only effective when the linear dimension of the grounded arm corresponds to about one-quarter wavelength of the emitted (or received) wave, for then the antenna will have a real impedance and will have sufficient radiation resistance to provide for effective propagation. On the other hand, when the length of the grounded arm no longer corresponds to about one-quarter wave length, it has been generally assumed that the radiation resistance of the antenna becomes so low that the radiating (or receiving) power decreases to such a considerable extent so as to render the antenna ineffective for efficient operation. Inasmuch as folded monopole antennae are often placed where access is practically impossible (i.e., at the top of a mast or of a building), it is difficult to modify their lengths once they have been installed.

Accordingly, it is an object of the invention to provide an improved folded monopole antenna system.

It is a further object of the present invention to provide a monopole antenna system of enhanced efficiency.

Another object of the invention is to provide a folded monopole antenna system which is usable over a whole range of wavelengths where it previously had been thought that a monopole antenna would be ineffective.

Quite unexpectedly, it has been found that the radiation resistance of a folded monopole antenna begins to markedly increase when the dimension of the grounded arm corresponds to greater than about $\frac{1}{36}$ of a wavelength (λ) of the emitted wave.

An exemplary antenna system in accordance with the invention making use of the above finding comprises a folded monopole antenna having a grounded arm of length corresponding to greater than at least about $\frac{1}{36}\lambda$, which appears to its feeding transmission line to be an inductive element, and capacitive tuning means for

matching the impedance of the antenna to its feeding line over a wide range of operating frequencies.

The invention itself, both as to its organization and method of operation, as well as additional objects and advantages thereof will become more readily apparent from a reading of the following description taken in connection with the accompanying drawing in which:

FIGURE 1 is a diagrammatic illustration of a system, showing a folded monopole antenna and in schematic form capacitive tuning means for matching the impedance of the antenna to the transmission line; and

FIGURE 2 is a view similar to FIGURE 1 but depicting a second version of capacitive tuning means for use with a folded monopole antenna.

Referring first to FIGURE 1, a representative folded monopole antenna system is shown to include an antenna 10, a U-shaped member having two spaced arms 12 and 13 interconnected by means of a conductive merging section 14. The arm 12 is connected at its free end to ground which may be a metal structure or the earth itself. At point 15, the arm 13 is shown to be connected to one lead of a two-wire transmission line 16 which may, for example, be a coaxial cable.

Preferably, the arms 12 and 13 should be substantially parallel and located at a small distance from each other as compared to the wavelength that is emitted. The antenna 10 may be formed from a strip of elementary wire, or, where ruggedness is required, from conductive metal pipe.

Experimentally, it has been determined that if the length of the grounded arm 12, which is designated by the dimension d , corresponds to greater than $\frac{1}{36}\lambda$ of the wave being emitted, then the radiation resistance will be a substantial quantity. On the basis of test data, the radiation resistance appears to increase as a function of the square of the frequency as d progressively corresponds to an increasingly greater percentage of λ . Put differently, after about $\frac{1}{36}\lambda$, the radiation resistance increases exponentially as the square of frequency. At the same time, the other resistance components of the antenna 10, namely the skin component R_k and the nominal resistance component R_a appear to respectively vary as a function of the square root of the frequency and linearly with the frequency. When the length of the grounded arm 12 is less than $\frac{1}{36}\lambda$, these relationships do not hold true.

As viewed from the feeding point 15, when the dimension d corresponds to a range of from about $\frac{1}{36}\lambda$ to $\frac{1}{6}\lambda$, the antenna will behave as though it were an element having a high inductive impedance. Accordingly, capacitive type tuning means may be employed to match the impedance of the antenna 10 to the transmission line 16 so that the antenna and transmission line will substantially be in resonance at any operating frequency in this range. The ability to tune with capacitive elements is especially advantageous inasmuch as inductive tuning elements interpose losses which degrade antenna system efficiency.

As shown in FIGURE 1, an adjustable capacitor 19 is coupled between the junction 15 of the arm 13 and ground, in shunt across the transmission line 16, and a second adjustable capacitor 21 is disposed serially in one lead of the transmission line just before the feeding point 15. The capacitors 19 and 21 are so positioned in order to preserve line balance. With this arrangement, the greater portion of impedance matching tuning is accomplished by the capacitor 19, whereas a fine tuning adjustment is made by the capacitor 21.

The capacitors 19 and 21 may, of course, be mounted in sealed weatherproof containers, and it has been found preferable to have the capacitor 19 mounted immediately adjacent the ground location so that the arms 12 and 13 are substantially the same length. It has further been

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found that when the dimension d corresponds to more than $\frac{1}{6}\lambda$, the capacitive tuning system shown in FIGURE 1 is not effective to match the antenna to the transmission line. This match may be then accomplished by closing a shorting switch 23, as shown in FIGURE 2, which when closed provides a short circuiting path between the two antenna arms 12 and 13. With this configuration, by simply closing the switch 23, the antenna may be tuned beyond $\frac{1}{6}\lambda$ of its overall length (viz dimension d) until the antenna 10 begins to assume a capacitance reactance as viewed by the transmission line from the feeding point 15.

From the foregoing description it will be apparent that there has been provided an improved folded monopole antenna system. Variations and modifications of the illustrated antenna system and components therefor will undoubtedly become apparent to those skilled in the art. Accordingly, the foregoing description should be taken as illustrative and not in any limiting sense.

What is claimed is:

1. An antenna system comprising

- (a) a folded monopole antenna having a single U-shaped structure consisting of a substantially uniform pipe having two spaced arm sections merged together by means of a top section, one of said arm sections being grounded and the other of said arm sections being coupled to a transmission line, the length of said grounded arm section being from $\frac{1}{8}\lambda$ to $\frac{1}{6}\lambda$ wavelength at the operating frequency and characterized in that said end of said arm which is coupled to said transmission line, when the end of said grounded arm is greater than $\frac{1}{8}\lambda$ of a wavelength presents a resistance component including a

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substantial radiation resistance which increases exponentially with frequency so that said antenna is viewed as an element having exclusively inductive reactance at said transmission line at said operating frequency, and

- (b) capacitive means for matching the impedance of said antenna to said transmission line.

2. The invention as set forth in claim 1, wherein said capacitive tuning means comprises a capacitor in series with said transmission line and a capacitor in shunt across said transmission line and coupled to ground.

3. The invention as set forth in claim 2, including a shorting switch for coupling said arms when the length of said grounded arm corresponds to greater than $\frac{1}{6}\lambda$ of the operating wavelength.

4. The invention as set forth in claim 2, wherein said arms are substantially parallel and substantially the same length.

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