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TWO-BAND HELICAL ANTENNA

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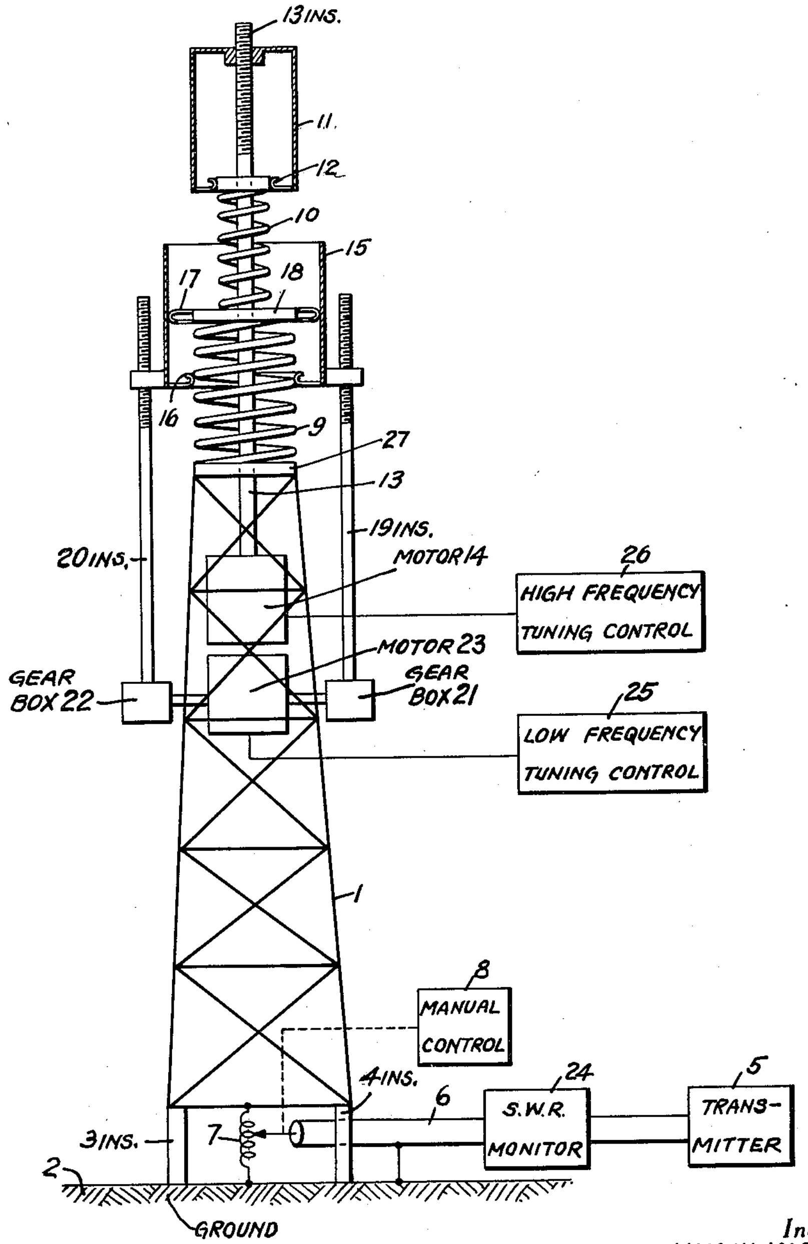

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TWO-BAND HELICAL ANTENNA

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This invention relates to tuned antenna systems and more particularly to a two-band tuned antenna capable of operating over a wide frequency range and utilizing a plurality of helical resonators.

In many applications it is required that the physical length of an antenna be small compared to the desired operating wavelength of associated transmitting or receiving equipment. It may also be required that the antenna be tunable over a very wide band of frequencies and that the standing wave ratio in the transmission line to the antenna be maintained close to unity over the wide band of frequencies. One application where both small antenna length and wide band tuning are required is on surface vessels where it is preferred to employ a sturdy structure insulated from the deck to radiate as an antenna having as great an effective height as possible. In such application the height of the structure is limited for practical reasons and it is preferable that the structure be resonated by some means that is tunable over a wide band of frequencies.

Heretofore helically top-loaded and capacitive top-loaded antennas have been employed to extend the effective electrical length of a radiator without adding appreciable physical height. The helical resonators employed in such antennas as top-loading have also been designed for operation over a wide frequency range by incorporating various methods of electrically shorting portions of the helical resonator and/or varying the capacitive top-loading members coupled to said helical resonators. It has also been the practice in the past to vary the point of input coupling to helically top-loaded radiators to improve impedance matching.

An object of this invention is to provide a tuned antenna system of high efficiency wherein the physical height of the radiator extending above the ground plane varies only slightly.

Another object of this invention is to provide a wide band tuned antenna system employing helical resonators.

Another object is to provide a helical antenna system which can be readily tuned over a wide band of frequencies.

Another object is to provide a tuned helical antenna system to extend the electrical length of a structure so as to make it resonant over a wide band of frequencies.

In accordance with a feature of this invention, the electrical length of a radiating body is varied to tune said body over a wide range of frequencies by coupling a plurality of helical resonators, one disposed above the other, to said body and providing means to vary the active portions of said helical resonators.

It is another feature of this invention to provide an adjustable shorting device to vary the active portion of one of said helical resonators for lower frequency tuning and to employ a second adjustable shorting device to vary the point of coupling of the capacitive top loading to the outermost of said helical resonators for higher frequency tuning and to provide different motor means to drive said first adjustable device and said second adjustable device.

Other and further objects and features of this invention will be more apparent by reference to the following description taken in conjunction with the accompanying drawing which is a side view of one embodiment of a two-band helical antenna in accordance with the principles of this invention.

Referring to the figure, there is shown a structure 1 disposed vertically above and insulated from a ground plane 2 by several insulators of which two are shown at 3 and 4. In the embodiment shown in the figure, the structure is employed to radiate energy; therefore, power from transmitter 5 is applied via coaxial line 6 to an impedance matching coil 7 which couples the bottom of structure 1 to ground with manual control means 8 being provided to vary the portion of coil 7 across which the input line is shunted. On top of structure 1 and electrically connected thereto is low frequency helical resonator 9, and disposed above resonator 9 and electrically coupled thereto is high frequency helical resonator 10 having top-loading capacitive member 11 disposed above and connected electrically thereto by means of spring fingers 12 which are arranged in a circle so as to provide positive electrical connection between capacitive member 11 and resonator 10 as capacitive member 11 is caused to move up and down by the rotary action of dielectric shaft 13 which is mechanically linked to high frequency tuning motor 14. Adjustable shorting shield 15, preferably of cylindrical shape and concentric with resonators 9 and 10, is provided with shorting spring fingers 16 at its bottom end which makes positive contact with resonator 9 as shorting shield 15 moves up and down with respect to resonators 9 and 10. Spring contact fingers 17, fastened to conductive coupler 18 which electrically connects resonator 9 to resonator 10, make positive contact with shorting shield 15 as the shield moves up and down with respect to fingers 17. Shorting shield 15 is caused to move up and down by the simultaneous rotary motion of dielectric rods 19 and 20 which are mechanically linked via gear boxes 21 and 22, respectively, to low frequency tuning control motor 23. The threaded portions of rods 13, 19 and 20 can be of metal. However, the part of rod 13 which is within helices 9 and 10 must be of dielectric material because of the powerful magnetic fields within helices 9 and 10. Similarly, there must be a portion of rods 19 and 20 that is made of dielectric material due to the difference of electrical potential between shield 15 and the structure at gear boxes 21 and 22.

In operation the structure 1 is energized by transmitter 5 via coaxial line 6 and coil 7 causing an indication on standing wave ratio monitor 24. Depending upon the output frequency of transmitter 5 and initial positions of capacitive member 11 and shorting shield 15, high frequency tuning motor 14 or low frequency tuning motor 23 can be energized as described below. If it is desired to tune structure 1 in the low frequency range, say, for example, between 300 kc. and 3 mc., low frequency tuning motor 23 will be energized from low frequency tuning control device 25 which may be merely a switch providing positive, negative or no electrical energy to motor 23. Upon energizing motor 23, standing wave ratio monitor 24 is observed by an operator who will operate control device 25 causing shorting shield 15 to move upwards or downwards until the standing wave voltage ratio in transmission line 6, as indicated by monitor 24, reaches a minimum. The standing wave ratio found in the above tuning process becomes a minimum when the antenna is resonant; thus, manual control 8 can now be adjusted to change the impedance match and further reduce the standing wave ratio toward its optimum value of unity. Frequently little or no adjustment of control 8 is required, and in many cases manual control 8 can be eliminated entirely by providing the proper size of coil 7 and connecting the coaxial line 6 across the entire coil 7. As the antenna system shown in the figure is tuned to higher and higher frequencies in the low frequency range, shorting shield **15** will be driven downward until contact fingers **16** reach the bottom of resonator **9**. Fine adjustment of the tuning in the low frequency range can be accomplished, if desired, by controlling the position of capacitive load **11** with its contact fingers **12** on the smaller helix **10** by means of motor **14** and high frequency tuning control **26**. Subsequently, further tuning to still higher frequencies in the high frequency range, say, for example, between 3 mc. and 30 mc., will be accomplished by energizing high frequency tuning motor **14** from high frequency tuning control device **26** which may be merely a switch applying positive, negative or no electrical energy to motor **14**. Motor **14** drives dielectric shaft **13** which is threaded at its upper end, in contact with top-loading capacitance **11**, so that as shaft **13** turns one way or the other, top-loading capacitive member **11** is caused to move upwards or downwards to increase or decrease the resonant frequency of the antenna device in the high frequency band. The operator controls high frequency tuning in the same manner he controls low frequency tuning, namely, by observing standing wave ratio monitor **24** and actuating the appropriate tuning control device **26** and further adjusting manual control **8** until the standing wave ratio in transmission line **6** is a minimum. In most applications where very wide band tuning is desired, high frequency range tuning is achieved in steps, the first step being to resonate the system at a quarter wavelength ($\lambda/4$) over a range of λ's, say from 3 mc. to 9 mc., by moving capacitance **11** from its top to its bottom position, the second step being to resonate the system at $3\lambda/4$ over the range of roughly 9 mc. to 15 mc. or higher, the third step being to resonate at $5\lambda 4$ over the range of roughly 15 mc. to 30 mc. and so forth, until the system is tuned over the range desired. It should be observed that, while tuning in the high frequency range by means of resonator **10**, the low frequency resonator **9** is completely isolated and shielded by means of shorting shield **15**, conductive coupler **18** and the conductive coupler **27** shown at the base of resonator **9**. For this reason conductive couplers **18** and **27** are solid metal disks except for a smal opening in each to accommodate dielectric shaft **13** and such structural bolts as may be required. Thus the natural resonant frequencies of resonator **9** are inhibited from influencing the tuning of resonator **10**.

While in the specific embodiment described hereinabove I have shown that both helices are positioned at the top of the structure **1**, it is also possible to separate the helices and position them at different points along the structure. One satisfactory arrangement is to place the high frequency helix **10** beneath the structure **1**, for example, in place of coil **7** and similarly connected to coaxial line **6** while leaving the low frequency helix **9** in the position indicated in the drawing. In this arrangement, the helix **9** will serve to resonate the structure in the low frequency range thus giving a substantially uniform current distribution along the structure for that range. For the frequencies of the high frequency range, the structure may, by itself, be sufficiently long to serve as an efficient radiator if the tower is electrically approximately one eighth to three quarter wavelengths long. Tuning of the high frequency helix may be performed by shorting out parts of it while impedance matching may be performed by selecting the point on said helix to which the coaxial line is coupled.

While I have described above the principles of my invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope of my invention as set forth in the objects thereof and in the accompanying claims.

I claim:

1. A radio antenna system comprising a vertical radiating member, a plurality of helices mounted one above the other on said member in substantial vertical alignment therewith said plurality of helices disposed in tandem relationship with each other and said vertical radiating member so that the cylinders formed by said helices do not overlap, the bottom and the top of adjacent helices of said plurality of helices being electrically coupled in a series relationship, and the bottom of the lowest helix of said plurality of helices being electrically coupled to the top of said member each of said helices having a different diameter, each of said helices having a different electrical length, means for shorting out a selectable amount of the electrical length the lower one of said adjacent helices of said connected helices of said shorting means including a shielding member to prevent undesirable coupling between said plurality of helices to tune said radiating member over a given frequency range, and variable means for shorting out a selectable amount of the electrical length of the upper one of said adjacent helices of said series connected helices to tune said member over a second frequency range.

2. A radio antenna system according to claim 1, wherein said upper one of said adjacent helices of said series connected helices has a shorter electrical length than said lower helix of said adjacent helices of said series connected helices and its shorting means tunes said member over a higher frequency range while the shorting means of said lower helix of said adjacent helices of said series connected series tunes said member over a lower frequency range.

3. A radio antenna system according to claim 2, wherein the shorting means for said upper one of said adjacent helices of said series connected helices is in the form of a shorting housing providing capacitive loading.

4. A radio antenna system comprising a first radiating member coupled at one end to a transmission line, a first helical member coupled to the other end of said first member, a second helical member coupled to said first helical member, adjustable shorting means coupling said first and second helical members, capacitive means disposed at one end of said second helical member and coupled thereto in a variable manner, and control means mechanically coupled to said shorting means and said capacitive member to adjust them and to tune said radiating member over a wide range of frequencies.

5. A radio antenna system as in claim 4 and wherein said adjustable shorting means further includes shielding means to shield varying portions of said second helical member as said adjustable shorting means is adjusted.

6. A radio antenna system comprising a radiating structure insulated from ground and coupled to a transmission line at its one end, a first helical member having its one end electrically coupled to the other end of said structure, a second helical member having its one end connected to the other end of said first helical member and disposed concentrically above, adjustable top loading coupled to the other end of said second helical member, adjustable shorting means coupling said one end of said second helical member to said first helical member, first motor means coupled to said shorting means, second motor means coupled to said top loading, and means to control said first and second motor means to tune said system over a wide band of frequencies.

7. A radio antenna system as in claim 6 and wherein said adjustable shorting means further includes shielding means coupled thereto to shield a varying portion of said second helical member as said adjustable shorting means is adjusted.

8. A radio antenna system comprising a vertically disposed structure insulated from ground and coupled to a transmission line by variable shunting means at one end of said structure, a low frequency helical resonator vertically disposed and coupled to the other end of said structure, a high frequency helical resonator vertically disposed above and coupled to said low frequency helical resonator, adjustable top-loading capacitive means coupled to said high frequency helical resonator, adjust-

able shorting means coupling the interjunction of said helical resonators to a variable number of turns of said low frequency helical resonator having shielding means attached thereto for shielding a variable number of turns of said high frequency helical resonator as said shorting means is adjusted, first motor means coupled to said top-loading capacitance, second motor means coupled to said adjustable shorting means, and control means associated with each of said motor means, the general arrangement of said system being such that said motor means may be energized to tune said system over a wide range of frequencies.

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