

May 7, 1963

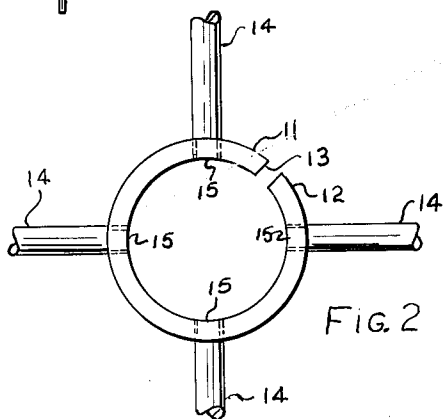
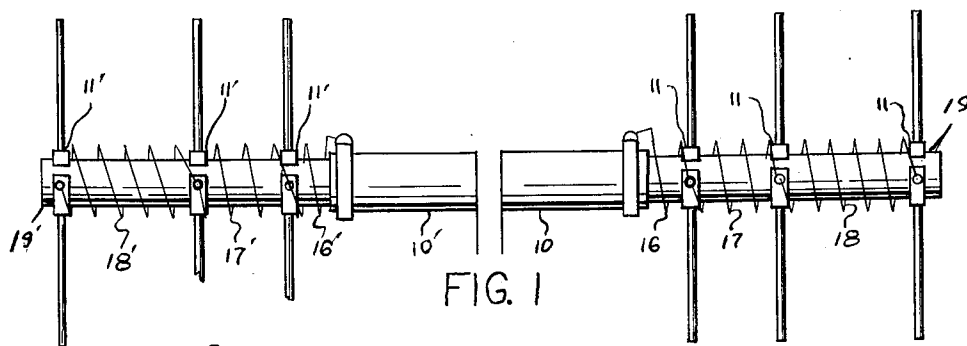
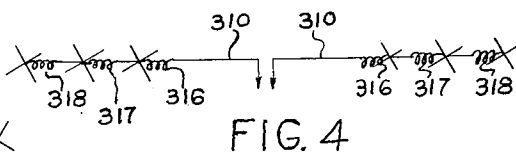
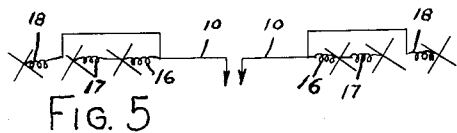
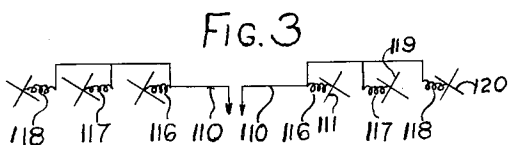
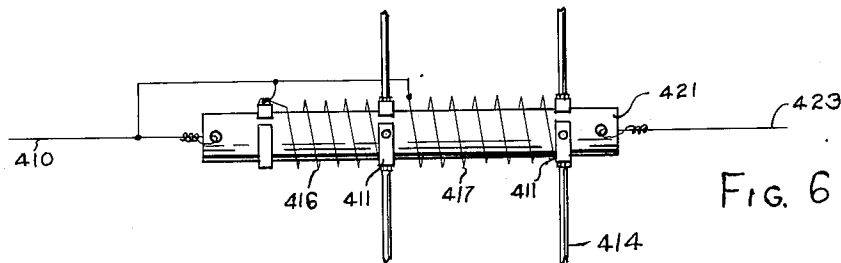
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3,089,140

MULTI-BAND ANTENNA WITH END MOUNTED LOADING SECTION

Filed July 22, 1959

2 Sheets-Sheet 1



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MULTI-BAND ANTENNA WITH END MOUNTED LOADING SECTION

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2 Sheets-Sheet 2

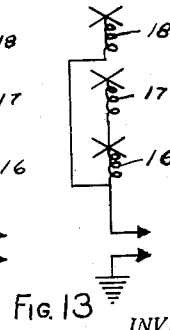
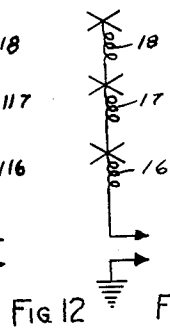
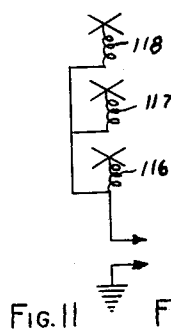
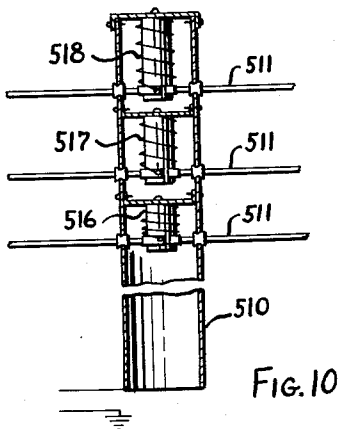
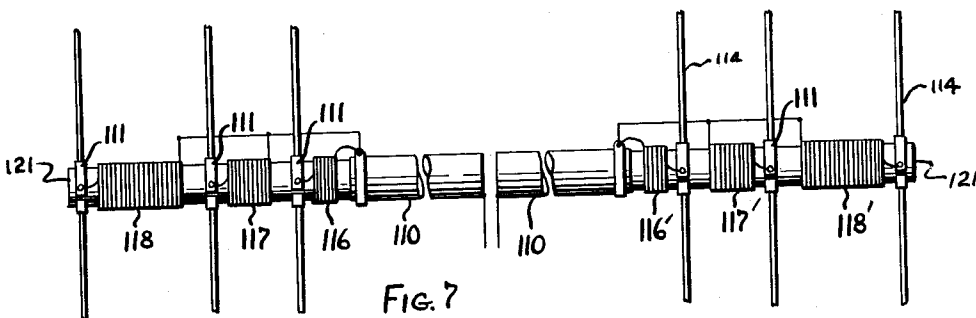
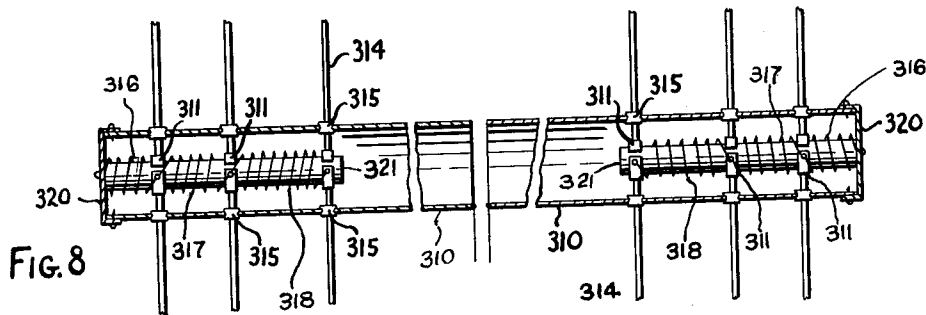
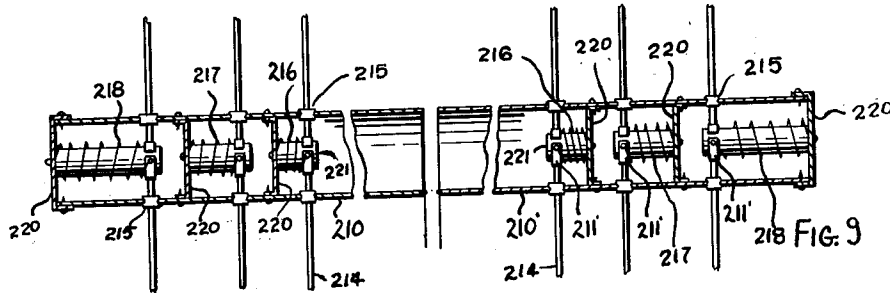


FIG. 11

FIG. 12

FIG. 13

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3,089,140 MULTI-BAND ANTENNA WITH END MOUNTED LOADING SECTION

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21 Claims. (Cl. 343-722)

This invention relates to antennas and, more particularly, to a multi-band antenna.

This application discloses a miniaturized multi-band antenna using series, parallel, or combination of series and parallel loading units mounted externally or in coaxial arrangement at or near the opposite ends of a length of wire, rod, or tubing, which is referred to herein as the radiator. The loading unit consists of a series connected inductor and loading capacitor, the inductor being of conventional design and the loading capacitor being of the "hat" variety. The drawings show several loading units connected in series, in parallel, and in combination of series and parallel.

In the dipole design, matched pairs of loading units symmetrically mounted on each end of the radiator are required for each additional frequency desired, these frequencies being in addition to the resonant frequency of the radiator itself. The antenna operates as an electrical half wave on all frequencies.

In the quarter wave vertical design, only a single loading unit is required for each additional operating frequency desired. The loading units are mounted at or near the top of the radiator externally or, if desired, internally, in a coaxial manner with the transmission line connecting to the opposite or bottom end of the radiator. A good ground, radials, or equivalent are desirable with this arrangement for attaching the transmission line shield. The antenna operates as an electrical quarter wave on all frequencies.

These single multi-band elements may be combined to form higher gain, directional multi-element arrays such as the two or three element yagi. When used in parasitic elements for such arrays, the center feed points should be short circuited.

The loading capacitor used in the multi-band design disclosed herein may be of cylindrical, disk, skeleton, or radial spoke construction. A modified radial spoke capacitor was developed for this antenna. As shown in the drawings, the capacitor consists of four radial spokes mounted in a split mounting ring. The number of spokes may be varied and is not critical, provided the required capacity is obtained. For instance, three spokes can be used if their length is increased or six spokes can be used if shortened spokes are used. As shown in the drawings, these spokes are threaded and screwed into the mounting ring, the spokes being thus easily removed or replaced for slight frequency changes if desired. The split ring serves to maintain the Q of the inductor which would otherwise be lowered due to the shortened turn effect if a closed mounting ring were used. With this antenna as with all antennas, it is desirable to maintain as high a Q as possible or practical to keep power losses at a minimum.

It is, accordingly, an object of the present invention to provide a multi-band antenna whose physical length is determined by the highest frequency of operation rather than the lowest frequency as in conventional multi-band antennas.

Another object of this invention is to provide an improved miniature antenna which is suitable for operation over a plurality of frequency bands.

Still another object of the invention is to provide an improved hat capacitor in combination with a multi-band antenna.

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Yet another object of the invention is to provide an improved hat capacitor.

A further object of the invention is to provide an improved multi-band antenna.

It is a further object of the invention to provide a multi-band antenna which is simple in construction, economical to manufacture, and efficient to operate.

Still a further object of the invention is to provide a miniature antenna using internally mounted loading coils.

With the above and other objects in view, the present invention consists of the combination and arrangement of parts hereinafter more fully described, illustrated in the accompanying drawings and more particularly pointed out in the appended claims.

In the drawings:

FIG. 1 shows a series connected half wave with coils mounted externally according to the invention;

FIG. 2 is a view of a loading capacitor used with the antenna shown in FIG. 1;

FIG. 3 shows a schematic parallel arrangement for a four band dipole antenna;

FIG. 4 is a schematic view of a series arrangement for a four band dipole antenna;

FIG. 5 is a schematic view of a series parallel connected dipole antenna for four band operation;

FIG. 6 shows a two section parallel connecting loading unit for use with a long wire antenna to provide three band operation;

FIG. 7 is a longitudinal cross sectional view of a typical parallel connected four band dipole covering the amateur 6-10-15 and 20 meter bands;

FIG. 8 is a series connected coaxial dipole antenna for four bands;

FIG. 9 is a longitudinal cross sectional view of a coaxial arrangement of a parallel connected dipole antenna for four band operation;

FIG. 10 shows a vertical parallel connected concentric antenna for four band operation;

FIG. 11 is a schematic view of a quarter wave vertical antenna using a parallel arrangement;

FIG. 12 is a schematic view of a quarter wave vertical antenna using a series arrangement; and

FIG. 13 is a schematic view of a quarter wave vertical antenna using a series parallel arrangement.

Now with more specific reference to the drawings, in the embodiments disclosed herein, both a schematic and a layout diagram are included for each general type of antenna disclosed. FIGS. 1, 4, and 8 shows series four band dipole antennas.

The miniaturized antenna shown in FIG. 1 is made up of an antenna radiator 10 which may be made of any good electrical conducting material suitable for use as an antenna. The radiator 10 should have a diameter sufficiently large to support coil forms 19 and a loading capacitor 11 sometimes referred to as a loading unit. The radiator 10 should also be large enough in diameter to withstand weather conditions. Typical dimensions for such an antenna are disclosed in connection with FIG. 7 herein. Coils 16, 17, and 18 are connected in series with the radiator 10. The loading capacitors 11 are supported on the coil forms 19 and connected to the connection between the coils 16 and 17, 17 and 18, and the coil 18 and the form 19.

The operation is as follows:

Sections 10 and 10' represent the radiator, its physical length being an electrical half wave at the highest frequency of intended operation. The inductors 16 and 16' present a high impedance and act as R.F. chokes at the resonant frequency of the radiator 10, thus isolating the remaining sections when operating on this frequency.

The inductors 16 and 16' and their associated loading

capacitors 11 combine with the radiator 10 to make their effective length resonant at the next lower frequency while the inductors 17 and 17' act as R.F. chokes to isolate the remaining sections at this second frequency.

The inductors 17 and 17' and their associated capacitors 11 combine with the inductors 16 and 16' and their capacitors and the radiator 10 to make their effective length resonant at a still lower frequency while inductors 18 and 18' act as R.F. chokes to isolate the remaining sections at this third frequency. At the fourth and lowest frequency, inductors 18 and 18' combine with the inductors 17 and 17', the inductors 16 and 16', their associated capacitors, and the radiator 10 to resonate at this frequency. In conventional top loading, the added inductance and capacity appear as a capacitive reactance to the radiator element, thus, in effect, lowering the radiator frequency. In the present system, additional inductance is added to the point where the added inductance of the loading unit appears as an inductive reactance, thereby acting as an R.F. impedance and isolating this added section at the first or original radiator frequency. A second frequency may also be found which is due to the added electrical length added to the radiator by this inductor and loading unit.

Additional sections may be added, if desired, provided the sections added are always lower in frequency, when measured by themselves, than the lowest frequency of the antenna without these additional sections. This requirement holds for all loading units added to the radiator.

As additional sections are added, the presence of the added inductors will, in effect, reduce the capacitive end effect of the lowest frequency section, causing the frequency of that section to increase somewhat. This in turn requires an increase in inductance or capacity of that section to offset the effect of the added inductor and capacitor. The antenna operates as an electrical half wave on all frequencies.

The loading capacitors 11 are shown in an enlarged view in FIG. 2. These loading capacitors are used in the multiband design and have a hollow cylindrical body as shown. The capacitor may be of disk, skeleton, or radial spoke design. The cylindrical body is in the form of a ring 12 made of conducting material adapted to fit over the non-conducting coil form and it is split at 13 as shown. The ring 12 may form a slip fit on the coil form and may be fixed in place by means of cement or the like.

Spokes 14 are likewise made of conducting material and reduced size threaded ends 15 are received in circumferentially spaced threaded holes with the shoulder of the spoke adjacent the reduced size end resting on the outer periphery of the ring 12. The capacitors shown in FIGS. 1 through 13 have four spokes mounted in the split ring 12; however, any suitable number of spokes could be used so long as the correct capacity is maintained. For example, three spokes can be used if the length of the spokes were increased accordingly or six spokes can be used if some of the spokes were shortened. Since the spokes are screwed in, they can be easily removed or replaced to make small frequency changes.

The split ring serves to maintain the Q of the inductor which would otherwise be lowered if a closed ring were used, due to the shorted turn effect.

In FIG. 4, a schematic series arrangement is shown and in FIG. 8, a series connected dipole coaxial arrangement is shown wherein a radiator 310 is connected to metallic disks 320 which are in turn connected in series with inductor coils 316, 317, and 318. These coils are each connected to one of the capacitors 311 and radial spokes 314 extend through the radiator 310 by way of insulating grommets 315.

FIG. 8 shows a coaxial arrangement of this antenna, the loading inductors being mounted inside the radiator in a coaxial manner as shown.

FIG. 6 shows a two section parallel connected loading unit which can be attached at an intermediate part and to the ends of a long wire radiator to provide three band operation. Two of these units would be required for half wave dipole operation or one for quarter wave operation. FIG. 6 shows a radiator 410 connected in parallel with coils 416 and 417 which are in turn connected to capacitors 411. The opposite end of a non-conducting coil form 421 is connected to a wire 423. The wire 423 can be attached to a structure to support the antenna.

FIGS. 3, 7, 9, 10, and 11 show parallel arrangements of four band miniaturized antennas. The antenna shown in FIG. 7 is made up of an antenna radiator 110 which may be of good electrical conduction material suitable for use in antennas with an outside diameter sufficient to support coil forms 119 and to withstand weather conditions. The radiator 110 may be made of rod, wire, or tubing. Tubing is used for the coaxial versions disclosed herein. The coil forms 119 will be made of non-conducting material.

In the arrangement shown in FIG. 7, sections 110 and 110' represent the radiator, its physical length being an electrical half wave at the highest frequency of desired operation and being somewhat longer than a conventional dipole at this frequency.

Inductors 116 and 116', 117 and 117', and 118 and 118' act as R.F. chokes at this frequency to isolate the loading capacitors 111 at this first frequency. The inductors 116 and 116' and their respective loading capacitors 111 combine with the radiator sections 110 and 110' to resonate at a lower frequency than the first frequency. The inductors 117 and 117' and their loading capacitors 111 operate at still another lower frequency than the first frequency but not necessarily lower than the second frequency. The inductors 118 and 118' and their loading capacitors operate on the fourth frequency. This also is lower than the first frequency but not necessarily lower than the second and third frequencies.

Additional sections of loading units may be added if desired, provided the additional sections are matched pairs and the extra frequencies desired are lower than the radiator frequencies.

This arrangement differs from the series arrangement in that as additional sections are added to the radiator, it is not necessary that they be successively lower in frequency as required of the series arrangement, only that they be lower in frequency than the sections 110 and 110' of the radiator itself.

An example of typical dimensions for the antenna shown in FIG. 7 which shows a typical four band dipole covering the amateur 6—10—15 and 20 meter bands is shown below:

110—4'11" long x 3/4" O.D., 5/8" I.D. aluminum tubing
110'—4'11" long x 3/4" O.D., 5/8" I.D. aluminum tubing
116—18 turns #18 wire
116'—18 turns #18 wire
117—33 turns #18 wire
117'—33 turns #18 wire
118—70 turns #16 wire
118'—70 turns #16 wire
111—Split ring capacitors each contain four radial spokes, 1/8" diameter x 6" long mounted 90° apart in split ring cemented to stearite coil form
Overall length including loading coils is 11'8"

In FIG. 9, a parallel connected antenna is shown with the loading coils mounted internally in a coaxial arrangement supported on mounting disks 220. The operation is, in general, like that of FIG. 7. The coils are supported inside a tube 210, the length of which is determined by the highest frequency of operation desired. The support disks 220 are made of metallic conductor material and coils 216, 217, and 218 will be connected to the disks 220, thereby connecting them to the radiator or tube

210. Coil forms 221 are made of non-conducting material.

The coaxial arrangement has the important advantage that the coils being arranged inside the tubular radiator, the antenna is, in effect, folded back on itself and thus can be made much shorter and compact physically than a plain straight single or multi-band antenna. Thus, a multi-band antenna can be made which is small, compact, and yet efficient. In prior folded antennas, the folds could not be folded close together because of cancellation effects.

The capacitors 211 will be connected to the coils as shown and they will be supported on the non-conducting forms which will, in turn, support the split rings. Insulating grommets 215 will insulate the spokes from the radiator 210.

FIG. 10 shows a quarter wave vertical antenna wherein in parallel connected coils 516, 517, and 518 are connected at their ends to capacitors 511 and to a radiator 510 through the supporting metal disks. The operation principle of this arrangement generally is as that of FIGS. 7 and 9 except one half is replaced by ground or equivalent. Any of the half wave dipoles shown can be operated as quarter wave antennas by replacing one half of the antenna with a ground or equivalent and feeding at this point.

The foregoing specification sets forth the invention in its preferred practical forms but it is understood that the structure shown is capable of modification within a range of equivalents without departing from the invention which is to be understood is broadly novel as is commensurate with the appended claims.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. An antenna comprising a radiator having an electrical length substantially equal to a quarter wave length of a predetermined frequency, an inductor connected to said radiator at or near the end opposite the feed point, and a loading unit having a single terminal only connected in series with said inductor and said radiator, said inductor having a sufficiently high impedance to act as an inductive reactance rather than a capacitive reactance at said predetermined frequency, said inductor and said loading unit acting as an additional electrical length to said radiator at a lower frequency than said predetermined frequency, thus providing operation on two different frequencies.

2. The antenna recited in claim 1 wherein a second inductor with a loading unit in series therewith is connected in series with said first mentioned inductor and loading unit, said second inductor being of a value to act as a radio frequency choke at said lower frequency and to act as an additional electrical length to said radiator and said first inductor and loading unit at a still lower frequency than said lower frequency, thus allowing operation on three frequencies.

3. The antenna recited in claim 2 wherein a third inductor and loading unit connected in series with each other and with said second inductor and said second loading unit is provided, thus allowing operation on four frequencies.

4. The antenna recited in claim 2 wherein a third inductor with a loading unit in series therewith is connected in parallel at the inductor end with said first mentioned inductor and to said radiator and acts as an additional electrical length to said radiator at a frequency lower than said radiator's predetermined frequency.

5. The antenna recited in claim 1 wherein a second inductor with a loading unit in series therewith is connected in parallel at the inductor end with said first mentioned inductor and loading unit, said second inductor being of a value to act as a radio frequency choke at said lower frequency and to act as an additional electrical length to said radiator at a still lower frequency than said lower

frequency and thus allowing operation on three frequencies.

6. The antenna recited in claim 5 wherein said radiator comprises a hollow metallic tube and said inductors comprise coils disposed inside said tube concentric thereto.

7. The antenna recited in claim 6 wherein a third inductor with a loading unit in series therewith is connected in parallel at the inductor end with said first and second mentioned inductors and to said radiator, thus providing operation on four frequencies.

8. The antenna recited in claim 1 wherein a second inductor with a loading unit in series therewith is connected in parallel at the inductor end with said first mentioned inductor and to said radiator, said second inductor being of a value to act as a radio frequency choke at said lower frequency and to act as an additional electrical length to said radiator at a still lower frequency than said lower frequency, thus allowing operation on three frequencies.

9. The antenna recited in claim 1 wherein a multiple of inductors with loading units in series therewith is connected in parallel at the inductor end with said first mentioned inductor and to said radiator to provide a multiple of frequencies lower than said radiator frequency.

10. An antenna comprising a tubular member, said tubular member being of electrical conducting material, an end plate on said tubular member, a core member of non-conducting material in said tubular member concentric therewith, a first and a second inductor on said core member, and a first and a second capacitor, each said capacitor being made in the form of a split ring, and radial spokes disposed on said core member, each said inductor being connected in series with one said capacitor and connected together and to said tubular member.

11. The antenna recited in claim 10 wherein one said capacitor and inductor are connected in series with the other said capacitor and inductor.

12. The antenna recited in claim 10 wherein both said capacitors and inductors are connected in series with said tubular member and in parallel with each other at the inductor ends.

13. The antenna recited in claim 12 wherein a third capacitor and inductor are connected in series with one said capacitor and inductor.

14. The antenna recited in claim 12 wherein said capacitors have spokes attached thereto extending radially therefrom and through openings in said tubular member.

15. The antenna recited in claim 14 wherein the antenna comprises an element of an antenna system and a second antenna matched to said antenna comprises another element of said system.

16. An antenna comprising a radiator having an electrical length substantially equal to a quarter wave length of a predetermined frequency, an inductor connected to said radiator at or near the end opposite the feed point, a loading capacitor connected in series with said inductor and said radiator, said inductor having a high impedance and acting as a radio frequency choke at said predetermined frequency, said inductor and said capacitor acting as an additional electrical length to said radiator at a lower frequency than said predetermined frequency, thus providing operation on two different frequencies, and a second inductor with a capacitor in series therewith connected in series with said first mentioned inductor and capacitor, said second inductor being of a value to act as a radio frequency choke at said lower frequency and to act as an additional electrical length to said radiator and said first inductor and capacitor at a still lower frequency than said lower frequency, thus allowing operation on three frequencies, said radiator comprising a hollow tube and said inductors comprising coils disposed inside said tube concentric thereto, said capacitors comprising rings having spokes extending radially through openings in said tube.

17. An antenna comprising a radiator having an electrical length substantially equal to a quarter wave length of a predetermined frequency, an inductor connected to said radiator at or near the end opposite the feed point, a loading capacitor connected in series with said inductor and said radiator, said inductor having a high impedance and acting as a radio frequency choke at said predetermined frequency, said inductor and said capacitor acting as an additional electrical length to said radiator at a lower frequency than said predetermined frequency, thus providing operation on two different frequencies, and a second inductor with a capacitor in series therewith connected in series with said first mentioned inductor and capacitor, said second inductor being of a value to act as a radio frequency choke at said lower frequency and to act as an additional electrical length to said radiator and said first inductor and capacitor at a still lower frequency than said lower frequency, thus allowing operation on three frequencies, said capacitors comprising split rings having spokes attached thereto and extending radially therefrom, said rings being disposed concentric to said radiator.

18. An antenna comprising a radiator having an electrical length substantially equal to a quarter wave length of a predetermined frequency, an inductor connected to said radiator at or near the end opposite the feed point, and a loading capacitor connected in series with said inductor and said radiator, said inductor having a high impedance and acting as a radio frequency choke at said predetermined frequency, said inductor and said capacitor acting as an additional electrical length to said radiator at a lower frequency than said predetermined frequency, thus providing operation on two different frequencies, said radiator comprising a hollow tube and said inductor comprising coils disposed inside said tube concentric thereto, said capacitor comprising rings having spokes extending radially through openings in said tube.

19. An antenna comprising a radiator having an electrical length substantially equal to a quarter wave length of a predetermined frequency, an inductor connected to said radiator at or near the end opposite the feed point, a loading capacitor connected in series with said inductor and said radiator, said inductor having a high impedance

and acting as a radio frequency choke at said predetermined frequency, said inductor and said capacitor acting as an additional electrical length to said radiator at a lower frequency than said predetermined frequency, thus providing operation on two different frequencies, and a second inductor with a capacitor in series therewith connected in parallel at the inductor end with said first mentioned inductor and capacitor, said second inductor being of a value to act as a radio frequency choke at said lower frequency and to act as an additional electrical length to said radiator at a still lower frequency than said lower frequency and thus allowing operation on three frequencies, said radiator comprising a hollow tube and said inductors comprising coils disposed inside said tube concentric thereto, said capacitors comprising rings having spokes extending radially through openings in said tube.

20. An antenna comprising a radiator having an electrical length substantially equal to a quarter wave length of a predetermined frequency, an inductor connected to said radiator at or near the end opposite the feed point, and a loading capacitor connected in series with said inductor and said radiator, said inductor having a high impedance and acting as a radio frequency choke at said predetermined frequency, said inductor and said capacitor acting as an additional electrical length to said radiator at a lower frequency than said predetermined frequency, thus providing operation on two different frequencies, said capacitor comprising a split ring having spokes attached thereto and extending radially therefrom, said ring being disposed concentric to said radiator.

21. The antenna recited in claim 20 wherein said ring is disposed inside said tube and said spokes extend through holes in said tube.

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