

Feb. 4, 1969

R. C. FENWICK

3,426,352

CAPACITIVELY TUNED REFLECTOR ANTENNA

Filed Aug. 26, 1966

Sheet 1 of 2

FIG 1

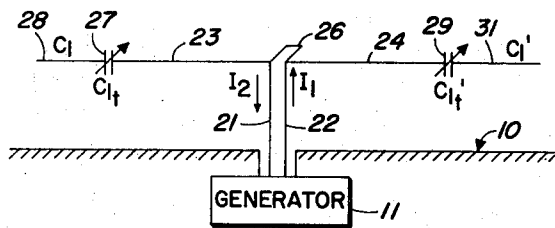
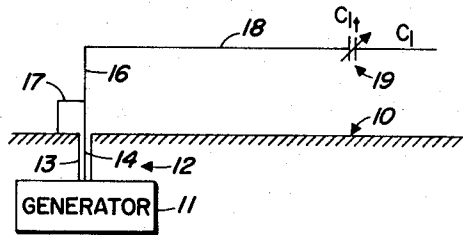


FIG 2

FIG 3

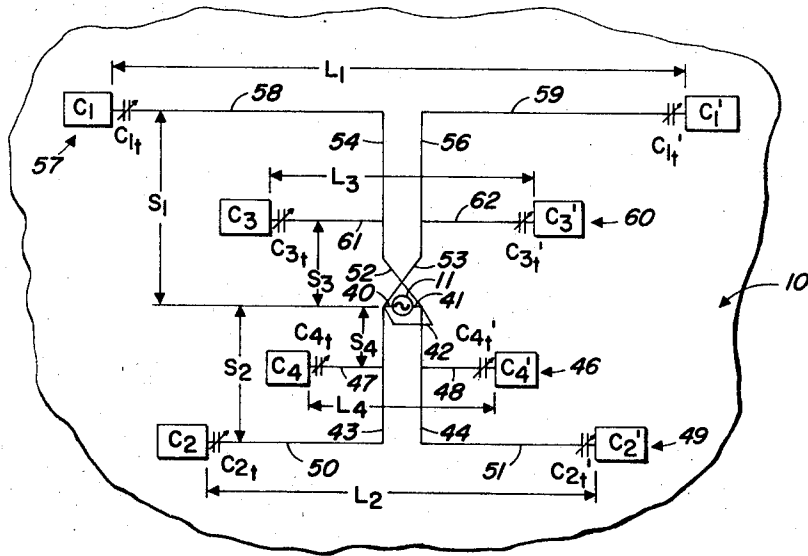
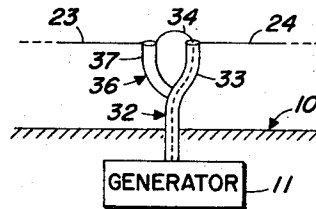


FIG 4

INVENTOR.
RICHARD C. FENWICK

BY

Marvin Moody
ATTORNEY

Feb. 4, 1969

R. C. FENWICK

3,426,352

CAPACITIVELY TUNED REFLECTOR ANTENNA

Filed Aug. 26, 1966

Sheet 2 of 2

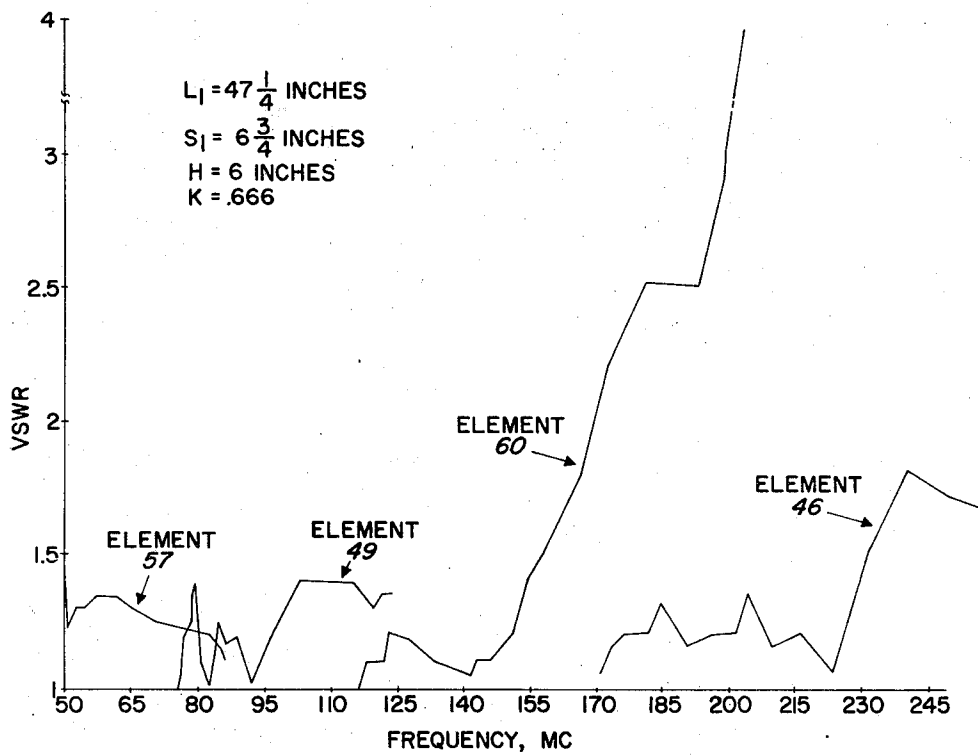
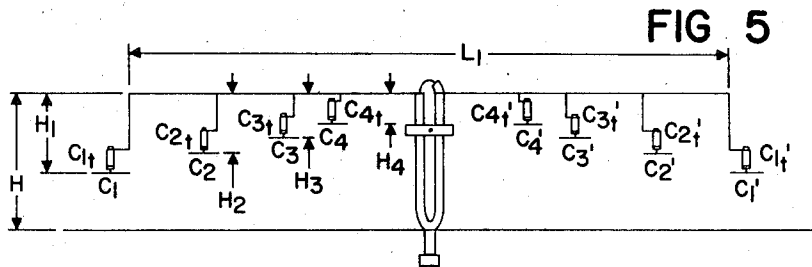


FIG 6

INVENTOR.
RICHARD C. FENWICK

BY *Mervin M. Moats*
ATTORNEY

1

3,426,352

CAPACITIVELY TUNED REFLECTOR ANTENNA
Richard C. Fenwick, Richardson, Tex., assignor to
Collins Radio Company, Cedar Rapids, Iowa, a
corporation of Iowa

Filed Aug. 26, 1966, Ser. No. 575,934

U.S. Cl. 343-750

9 Claims

Int. Cl. H01q 9/12

This invention relates in general to antennas and, in particular, to an antenna which may be tuned over a wide band with a low voltage standing wave ratio and unidirectional radiation pattern.

It is an object of this invention to provide an antenna capable of being tuned over a broad band of frequencies and which gives a good voltage to standing wave ratio over the frequency range.

Another object of this invention is a provision for an improved multielement broadband antenna with electrically small dimensions.

A feature of this invention is found in the provision for a plurality of capacitively loaded multiple antenna elements which are so connected to form a composite antenna which is tunable over a broad frequency range and which has a good standing wave ratio.

Further objects, features, and advantages of this invention will become apparent from the following description and claims when read in view of the accompanying drawings, in which:

FIGURE 1 illustrates a capacitively tuned antenna;

FIGURE 2 shows a pair of antennas such as shown in FIGURE 1 connected together;

FIGURE 3 shows a modification of the feed system of the antenna in FIGURE 2;

FIGURE 4 shows the novel multielement antenna of this invention;

FIGURE 5 is a side view of the antenna; and,

FIGURE 6 is a plot of the voltage standing wave ratio versus frequency for a particular antenna.

FIGURE 1 illustrates an antenna which is the subject matter of my copending application entitled "Capacitively Tuned Electrically Small Antenna" filed Dec. 27, 1965, Ser. No. 517,111, now abandoned. Such antenna comprises an element mounted above a ground screen or reflecting screen 10 through which coaxial feedline 12 extends. Line 12 has an outer conductor 13 and an inner conductor 14. A suitable radio frequency generator 11 is connected to the coaxial cable 12. A relatively short feed portion 16 extends outwardly from the ground screen 10 and connects to the inner conductor 14 of the coaxial cable. A matching inductor 17 is connected between the ground screen 10 and the portion 16. A conducting element 18 is bent at right angles to the ground screen and connects to the portion 16. A variable capacitor 19 is connected at the other end of the conductor 18 and a capacitor plate C_1 is attached to the other side of the variable condenser 19.

As pointed out in the copending patent application referred to above, such an antenna is tunable over a wide frequency band and has a low voltage standing wave ratio and radiates primarily as a vertical monopole parallel to the ground plane. By combining a pair of these antennas into a balanced structure over a ground plane as shown in FIGURES 2 and 3, an antenna with completely different characteristics is obtained.

In FIGURE 2, the generator 11 is connected through a balanced feedline having conductors 21 and 22 to conductors 23 and 24. A matching inductor 26 is connected between the end feedlines 21 and 22. The conductors 23 and 24 extend parallel to the ground screen 10. Condenser 27 is connected to the other end of the conductor

2

23 and a capacitive plate 28 is connected to the other side of the condenser 27. Likewise, a variable condenser 29 is connected to the other end of conductor 24 and capacitor plate 31 is connected to the other side of the condenser 29.

FIGURE 3 illustrates a modification of the antenna of FIGURE 2 wherein a coaxial cable 32 is connected to the generator 11 and has its outer conductor 33 connected to ground and to the end of element 24 and its inner conductor 34 is connected to element 23. A stub coaxial cable 36 has its outer conductor 37 connected to the element 23 and joins the coaxial cable 32 at a point intermediate its ends.

The antennas of FIGURES 2 and 3 are the same except for the type of feed and these antennas give a unidirectional radiation pattern oriented perpendicular to the ground screen or reflecting screen. Radiation parallel to the reflecting screen is negligible due to the out-of-phase currents I_1 and I_2 in the feedlines 21 and 22. However, the antennas of FIGURES 2 and 3 do not give good voltage standing wave ratios when tuned over a wide band because of the unfavorable variation of radiation resistance with frequency. It has been discovered that this limitation can be overcome by combining two or more elements such as shown in FIGURES 2 and 3 into a composite antenna in which each element has a proper length to cover a relatively small frequency band.

FIGURE 4 illustrates such an antenna from the top view. The ground reflecting screen 10 lies in the plane of the drawing and a generator 11 has a pair of feedlines 40 and 41 which extend outwardly from the ground plane. A matching inductor 42 is connected across the ends of feedlines 40 and 41 and a first pair of antenna element feedlines 43 and 44 extend parallel from the ends of feedlines 40 and 41 as shown. A first high frequency antenna element 46 is connected to feedlines 43 and 44. Antenna 46 comprises a pair of radiating elements 47 and 48 which extend, respectively, outwardly from feedlines 43 and 44 and variable capacitors C_{4t} and C_{4t}' are connected to the end of leads 47 and 48. Capacitor plates C_4 and C_4' are attached to the other sides of condenser C_{4t} and C_{4t}' .

A lower frequency antenna 49 is mounted further from the end of feedlines 40 and 41 on feedlines 43 and 44 and comprises a pair of antenna elements 50 and 51 with variable capacitors C_{2t} and C_{2t}' at the ends of elements 50 and 51 and capacitive plates C_2 and C_2' connected to the other sides of these condensers.

Also connected to the end of feedlines 40 and 41 are crossover phase reversing leads 52 and 53 which connect to feedlines 54 and 56 which extend in a direction opposite from feedlines 43 and 44 from feed points 40 and 41. The lowest frequency antenna element 57 is connected to the end of feedlines 54 and 56 and comprises radiating elements 58 and 59 which have variable capacitors C_{1t} and C_{1t}' at their ends and capacitive plates C_1 and C_1' connected to the condensers. A relatively high frequency antenna element 60 is also connected to feedlines 54 and 56 and comprises radiating elements 61 and 62 with capacitors C_{3t} and C_{3t}' connected to their ends, respectively, and with capacitive plates C_3 and C_3' connected to these capacitors. It is to be noted that the antenna of FIGURE 4 illustrates four antenna elements of the type shown in FIGURES 2 and 3 which form a composite antenna that may be used to radiate or receive energy over a broad frequency spectrum with a low voltage standing wave ratio. The length and spacing and usually the width of each of the elements are related to those of the adjacent band element by a scaling factor K . In other words, if the length of each of the antenna elements 46, 49, 57 and 60 is indicated by L_1 , L_2 , L_3 and L_4 , respectively, the following relationships exist:

$$L_2=KL_1, L_3=KL_2 \text{ and } L_4=KL_3$$

If the distance from the feedlines 40 and 41 to the radiating elements of each antenna is designated S_1, S_2, S_3 and S_4 for each of the antennas 46, 49, 57 and 60, respectively, the following relationships also hold:

$$S_2=KS_1, S_3=KS_2, S_4=KS_3$$

K is equal to f_1/f_2 where f_1 is the center frequency to which a particular one of the antenna elements can be tuned and f_2 is the center frequency to which the next higher frequency antenna element can be tuned. In general,

$$K = \frac{f_0(n)}{f_0(n+1)}$$

where n is the element number. The dimensions of the end plates C_1 and C_1', C_2 and C_2', C_3 and C_3', C_4 and C_4' do not generally scale in this manner but are made just large enough so that a given element can be resonated at the lowest frequency in its band with its tuning variable capacitors at their maximum values.

The antenna elements are spaced about the feed point so that element to feed point spacing S may be as small as possible while the spacing between elements of adjacent frequency band antenna elements may be as great as possible. Crossing over (transposing) the feedline as illustrated by leads 52 and 53 is preferable, but is not required for operation.

FIGURE 5 is a view taken at right angles to FIGURE 4 and illustrates a modification which may be made wherein the heights of the end plates $C_1, C_2, C_3, C_4, C_1', C_2', C_3'$ and C_4' were not held constant but were related to one another by the scaling factor K. In other words,

$$H_2=KH_1, H_3=KH_2, H_4=KH_3$$

This is preferred, but not required.

FIGURE 6 is a plot of voltage standing wave ratio versus frequency for a particular antenna with four elements and it is to be noted that generally the standing wave ratio over the frequency range from 50 to 230 megacycles is less than 1.5. The voltage standing wave ratio is below 2 over a 5:1 frequency band.

It is seen that this invention provides a driven antenna over a ground screen or reflector in a broadside radiation configuration which can be tuned by means of variable capacitors over a wide band, while maintaining a good voltage standing wave ratio and a good radiation pattern. The antenna may be spaced close to the reflector and in one embodiment has a simple means to feed the balanced antenna with an unbalanced transmission line.

Although the antenna has been described with respect to particular embodiments thereof, it is not to be so limited, as changes and modifications may be made therein which are within the spirit and scope of the invention as defined by the appended claims.

I claim:

1. A broadband antenna comprising a ground plane, a pair of feedlines extending outwardly from the ground plane, a second pair of feedlines connected to the ends of the first pair of feedlines and extending substantially

parallel to the ground plane, a first antenna element connected to the second pair of feedlines and comprising first radiating elements, a first pair of variable capacitors connected to the ends of the radiating elements, a first pair of capacitor plates connected to the first pair of variable capacitors, a second antenna element connected to the second pair of feedlines and comprising second radiating elements, a second pair of variable capacitors connected to the ends of the second radiating elements, and a second pair of capacitor plates connected to the second pair of variable capacitors.

2. In apparatus according to claim 1, a third pair of feedlines connected to the ends of the first pair of feedlines and extending substantially parallel to the ground plane and a third antenna element connected to the third pair of feedlines and comprising third radiating elements, a third pair of variable capacitors connected to the third radiating elements, and a third pair of capacitor plates connected to the third pair of variable capacitors.

3. In an antenna according to claim 2, additional radiating elements connected to the feedlines and each element having variable condensers attached to their ends and capacitor plates attached to each of the variable condensers.

4. In an antenna according to claim 3, wherein all of the radiating elements and their associated condensers are tuned to different center frequencies.

5. In apparatus according to claim 4, wherein the lengths of each radiating element bears a relationship to its adjacent frequency radiating element determined by a constant scaling factor.

6. In apparatus according to claim 4, wherein all of the radiating elements are spaced from the first pair of feedlines by distances which are related to the center frequencies radiating elements that are resonant at adjacent frequencies.

7. In apparatus according to claim 3, wherein the third pair of feedlines are transposed adjacent their junction with the first pair of feedlines.

8. In apparatus according to claim 4, wherein the capacitor plates of various radiating elements are spaced varying distances from the ground plane.

9. A broadband antenna comprising a ground plane, a pair of feedlines extending outwardly from the ground plane, an antenna element comprising radiating elements each connected to one of the feedlines, a pair of variable capacitors connected to the ends of the radiating elements, and a pair of capacitor plates connected to the pair of variable capacitors.

References Cited

UNITED STATES PATENTS

3,151,328 9/1964 Boyer ----- 343-752

55 ELI LIEBERMAN, *Primary Examiner*.

U.S. Cl. X.R.

343-752, 792.5, 829