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MULTI-FREQUENCY ANTENNA

Filed March 25, 1953

FIG. 1

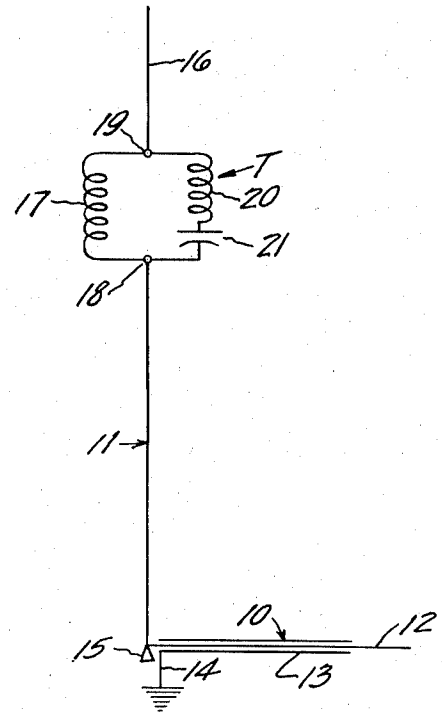


FIG. 3

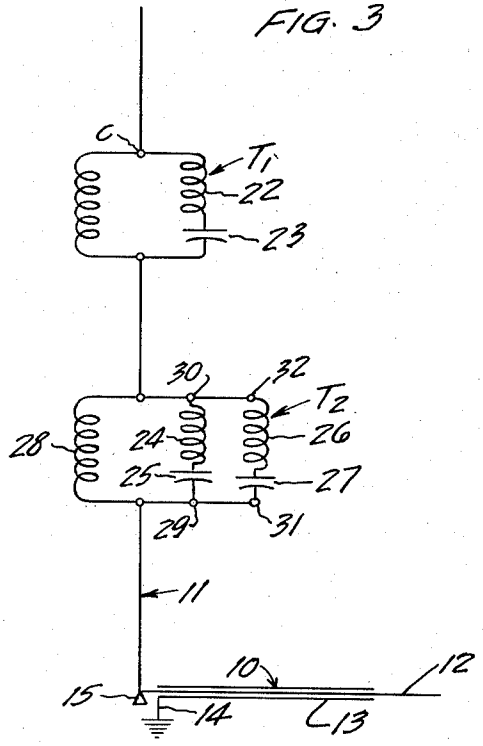


FIG. 4

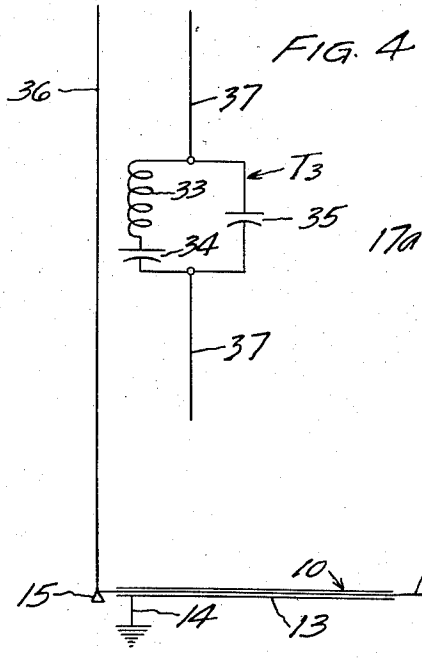
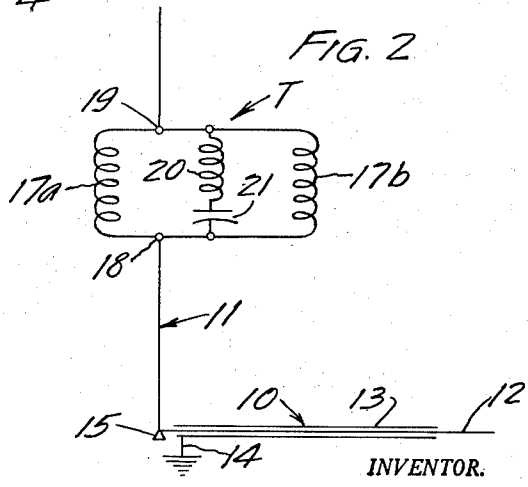


FIG. 2



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MULTI-FREQUENCY ANTENNA

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2 Claims. (Cl. 343—722)

This invention relates to multi-frequency antennas and more particularly to an antenna including a tuning network which is capable of transmitting and receiving waves of more than one frequency.

It is a well known feature of radio operation that the antenna system in connection therewith be resonant at the frequency of operation. Although transmitters and receivers can operate with antenna which are not so resonant, it is desirable to secure the maximum radiation which the antenna is capable of delivering and this can be accomplished only under resonant conditions. Sometimes it is desired that the same antenna system be capable of transmitting or receiving signals selectively at one or more frequencies. Such is often the case with amateur radio operators and in the case of aircraft radio operation and, sometimes, military radio communication. In some cases, it is desired to transmit from an antenna system at one frequency and to receive on the same antenna system at another frequency. In the case of extra hazardous operations, such as in connection with military or naval campaigns, it becomes desirable to maintain ordinary communication at one signal frequency and to maintain a condition such that a distress signal or other urgent communication may cut in or be transmitted between two points at a frequency other than the regular operating one.

In these and many other situations where a multi-frequency operation is desirable, the conventional means of attaining such operation has generally been accomplished by several expedients.

The first of these is the obvious solution of maintaining a separate antenna system for each frequency. Obviously, such an arrangement is expensive and multiplies the maintenance problem in connection with both transmission and reception.

The second conventional means of multi-frequency transmission and reception requires mechanism for switching in the tuning network of an antenna system. Since the network is often located inconveniently at a midpoint of a vertical antenna, the mechanical switching must be accomplished by such means as relays which in turn must be remotely controlled. Here again the method of switching is costly and adds extra working mechanism subject to failure and requiring additional maintenance.

The third conventional means of attaining resonant transmission and reception at a plurality of frequencies lies in a tuneable network located at the transmitter or receiver and used in conjunction with a resonant conductor connecting with the antenna system. The latter requires a variable length antenna in order to obtain resonance at various frequencies and does not ordinarily lend itself to an efficient mode of operation. One common useage of the latter mode of frequency switching occurs in aircraft transmission and reception where an antenna is unreeled from the airplane and allowed to trail therebehind at a fixed distance. As the network

is tuned, the antenna may be reeled in or reeled out to a preselected position such as to create a resonant condition. It will be noted that none of the foregoing conventional antenna systems provides for transmitting or receiving at more than one frequency without the use of a costly and cumbersome switching set-up to attain the desired resonant conditions at the various operating frequencies.

It is, therefore, an important object of the invention to provide for an antenna system which is capable of transmitting or receiving radio signals on more than one preselected frequency, the interchange between frequencies being accomplished without recourse to mechanical switching devices and without resorting to the use of a resonant transmission line.

It is another object of the invention to provide for a tuning network within an antenna system which will automatically provide for resonance at more than one preselected operating frequency.

It is a further object of the invention to provide for an antenna system which can operate on several preselected frequencies without resorting to the use of a resonant transmission line and without requiring physical switching at any position along the transmission line or within the tuning network, yet which will yield an ideal resonant condition whenever a transmitting or receiving signal of one of the preselected frequency values is applied to the antenna system.

These and other objects and advantages of the invention will more fully appear from the following description made in connection with the accompanying drawings wherein like reference characters refer to similar parts throughout the several views and in which:

Fig. 1 illustrates a quarter-wave antenna using my system for resonating at two different frequencies without switching or otherwise changing the physical dimensions thereof;

Fig. 2 illustrates the system of Fig. 1 with extra circuit element added to clarify evolution of the system;

Fig. 3 shows an extension of my invention in which the tuning network will provide for radio waves of three different frequencies, the system resonating at each of its frequencies; and

Fig. 4 shows still another application of my invention in which a parasitic element is included in the multi-frequency antenna system also without requiring switching or change in the physical dimensions of the antenna in order to produce resonance at the various frequencies.

Referring now to the drawing, I show the simplest form of my invention in Fig. 1. However, for the purpose of clarification and depicting the evolution of the system, reference is made to Fig. 2, which is equivalent to Fig. 1 with the addition of inductor **37**. The antenna shown in Figs. 1 and 2 is generally of the grounded quarter-wave type which is particularly adaptable to the very high frequency range of radio signals. The device comprises a coaxial transmission line **10** which is connected to the transmitter or receiver (not shown) and leads to the lower end of an antenna conductor or segment **11** as shown. The coaxial transmission line comprises a conductor **12** encased in and insulated from a metallic tubular member **13** which, in turn, is grounded at **14**. The conductor **12** connects with the antenna segment at a mounting insulator **15** as shown. A tuning network T is interposed in the antenna segment **11** and is preferably positioned so that a portion **16** of the antenna segment will extend above the tuning network T.

Referring to the form shown in Fig. 2, the tuning network T of itself comprises a first inductor **17***a* and a second inductor **17***b* which are connected to terminals **18** and **19** of the antenna segment **11**. In shunting rela-

tion with the inductors **17***a* and **17***b* is a third inductor **20** and a capacitor **21** connected in series combination. The latter two elements are likewise connected to terminals **18** and **19**, but sufficiently far away from the inductors **17***a* and **17***b* to prevent electrical coupling. The entire antenna system is so devised as to resonate at two frequencies designated as **F1** at the lower frequency and **F2** at the higher. The length of the conductor or segment **11**, including the upper portion **16**, is so selected as to be resonant at the higher frequency **F2**. The values of the reactances of capacitor **21** and inductor **20** are so selected that series resonance at the higher frequency **F2** occurs between the terminals **18** and **19**. It will be observed that, since a series-resonant circuit offers a very low impedance (zero theoretically) at the resonant frequency, an electrical short is provided across the terminals **18** and **19** which will still leave the conductor or segment **11** resonant at the higher frequency **F2**.

Because there is very low impedance across the terminals **18** and **19** of the antenna conductor or segment **11** at the resonant frequency **F2**, the circuit elements **17***a* and **17***b* will have no effect upon the behavior of the antenna system at the higher frequency **F2**. However, the inductor **17***b* is of such a value which, in conjunction with the inductor **20** and capacitor **21**, will form a parallel resonant circuit across the terminals **18** and **19** at the lower frequency **F1**. Since a parallel resonant circuit presents infinite impedance across its terminals, the series combination of the inductor **20** and the capacitor **21** is, to all intents and purposes, not effectively connected across the terminals **18** and **19** at the lower frequency **F1**. The magnitude of inductance value in inductor **17***a* is selected so that in conjunction with antenna segment **11** the system is resonant at its lower frequency **F1**. It should be noted that the parallel combination of inductors **17***a* and **17***b* with inductor **20** and capacitor **21** is not, in itself, resonant at the lower frequency **F1**.

In the practical application of my antenna system, inductors **17***a* and **17***b*, are combined in their parallel equivalent, inductor **17** (Fig. 1), and I provide for variation in the settings of inductors **17** and **20** as well as in capacitor **21**. It is understood, however, that when these elements have been pre-set for two selected frequencies in the light of surrounding factors which may vary to some degree the value of the settings, they need not be altered until such time as it is desired to operate on two other frequencies or under such other circumstances as will affect the values of the physical dimensions in the system.

When used on a mobile vehicle, the quarter-wave antenna may use the frame of the vehicle such as an automobile for a mirror reflecting surface which will complement the quarter-wave antenna system so as to effectively produce the half-wave which is requisite for resonance. Where the transmission line **12** is very short and constant in nature, it may enter into the antenna system. However, in order to prevent introducing unnecessary variables into my device, I prefer the grounded coaxial cable which prevents the transmission line from participating in radiation.

A specific example of values which I have successfully employed to achieve my multi-frequency transmission and reception are given below as follows. Referring again to Fig. 1, the transmission line which I employed was an R.G.–8 Bar U coaxial (51 ohms) grounded at the outer end and the conductor of the transmission line connected to the bottom of an insulated antenna conductor or segment one-quarter inch in diameter and thirty-seven and seven-eighths inches long to the terminal **18**. The remainder of the antenna conductor or segment **11** was fifty-five and five-eighths inches long by one-eighth inch in diameter. It should be noted that the diagrammatic representation in Fig. 1 does not necessarily correspond proportionally to the values given in this specific

example. The network T comprised an inductor **17** which was physically one and seven-sixteenths inches in diameter and two and one-quarter inches long and has an inductance value of 2.21 microhenrys. The inductor **20** was physically one and seven-eighths inches long and seven-eighths inch in diameter, having an inductance value of 0.845 microhenry. The capacitor **21** had a capacitance of 36 micromicrofarads when installed upon an automobile in conventional manner, the system resonated on a lower frequency **F1** of 14.2 megacycles and likewise resonated at a higher frequency **F2** of 29 megacycles, the system resonating as a quarter-wave antenna working against a ground plane.

Referring now to Fig. 3, I have there shown an example of a three frequency antenna system embodying my invention. In this case, I desire to resonate the antenna system at three frequencies designated as **F1**, **F2** and **F3** in increasing order. The connection between the coaxial cable **10** with the antenna conductor or segment **11** is the same as that disclosed in the diagrammatic representation of Fig. 1; the insulator **15** and ground connection **14** being similarly arranged. In the three frequency system, however, the tuning network may be divided into sub-networks such as an upper network **T1** and a lower network **T2** interposed in series within the antenna conductor or segment **11**. In this case, the inductor **22** and capacitor **23** are of such a value as to resonate at the highest frequency **F3**. The inductor **24** and the capacitor **25** are of such a value as to resonate also at the highest frequency **F3**. The inductor **26** and the capacitor **27** are of such values as to be series-resonant at the intermediate frequency **F2**. Inductor **28** is electrically shorted on the intermediate and highest frequency **F2** and **F3** by series circuits across terminals **29—30** and **31—32**. The inductor **28** has an inductance value which will resonate the entire system at the lowest frequency **F1**.

The foregoing illustration resonates the entire system upon the application of each of the above mentioned three frequencies, operating as a quarter-wave antenna against either ground or a ground plane.

Referring now to Fig. 4, I show therein an extension of my network technique to a parasitic system. In this case, the parasitic or driven element comprises a pair of arms **37** and a network **T3** in spaced relation with an antenna **36**, the transmission line and ground system being similar to that shown in Figs. 1 and 2. The tuning network **T3**, however, comprises a slightly different arrangement of conductors. In this instance, **T3** has, as one of its conductors, an inductor **33** and a capacitor **34** in series. A second conductor comprises another capacitor **35** which is in parallel with the elements **33** and **34**. The antenna or driving element **36** is mounted close to the parasitic element and may comprise either a director or reflector as is common in the art. The inductance **33** and capacitance **34** are made series resonant at the lower preselected frequency. The arms **37** of the parasitic element are selected so as to have a correct corresponding electrical length, thus shorting the element across the network terminals. The combination of values of inductance **33**, capacitance **34** and capacitance **35** is chosen to present the proper value of reactance at a higher preselected frequency so as to tune the parasitic element at the higher frequency. In the special case where the lower frequency is exactly half of the higher frequency, the combination results in parallel resonance across the terminals of the tuning network **T3** at the higher of the two frequencies. The capacitors **34** and **35** are made variable to facilitate adjustment of tuning on the lower and higher frequencies respectively.

It may thus be seen that I have devised a simple and trouble free antenna system which is capable of transmitting or receiving signals of more than one preselected frequency without providing separate antennas and mechanical switching mechanism for activating one or the

other of several such antennas. In accomplishing the foregoing, I have maintained a resonant condition for each of the preselected operating frequencies.

It will, of course, be understood that various changes may be made in the form, details, arrangement and proportions of the parts without departing from the scope of my invention.

What I claim is:

1. An antenna system adapted for connection with a coaxial cable for antomatically accommodating a plurality of radio signals of preselected frequencies, comprising an antenna segment having a plurality of adjacent sections, one of which is connected to the coaxial cable, a plurality of tuning networks each providing series interconnection between adjacent sections of said antenna segment, each of said networks including an inductance of preselected value and each also including a first series-connected inductance and capacitance of preselected value and connected in shunting relation with said first-mentioned inductance, one of said networks being connected into the antenna segment between the coaxial cable and another of the networks and also including a second series-connected inductance and capacitance of preselected values connected in shunting relation with said first mentioned series-connected inductance and capacitance, said preselected values of inductance and capacitance creating a resonant condition at each of said preselected frequencies without requiring mechanical switching or change in physical dimension of said antenna system, whereby a plurality of signals of different frequencies may be supplied to and transmitted by said antenna segment.

2. An antenna system for automatically accommodating a plurality of radio signals of preselected frequencies comprising an antenna segment having first, second and third sections, said first section being connected to the coaxial cable, a first tuning network connected between said first and second antenna sections, a second tuning network connecting said second and third antenna sections, each of said networks including an inductance of pre-selected value and each also including a first series inductance-capacitance circuit resonant at a first frequency and connected in shunt relation with said first mentioned inductance and said first tuning network also including a second series inductance-capacitance circuit resonant at a second frequency and connected in shunting relation with the inductance of the first network, said second tuning network being resonant at said second frequency and the first tuning network being resonant at a third frequency whereby to permit signals of three frequencies to be supplied to and transmitted by said antenna segment.

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