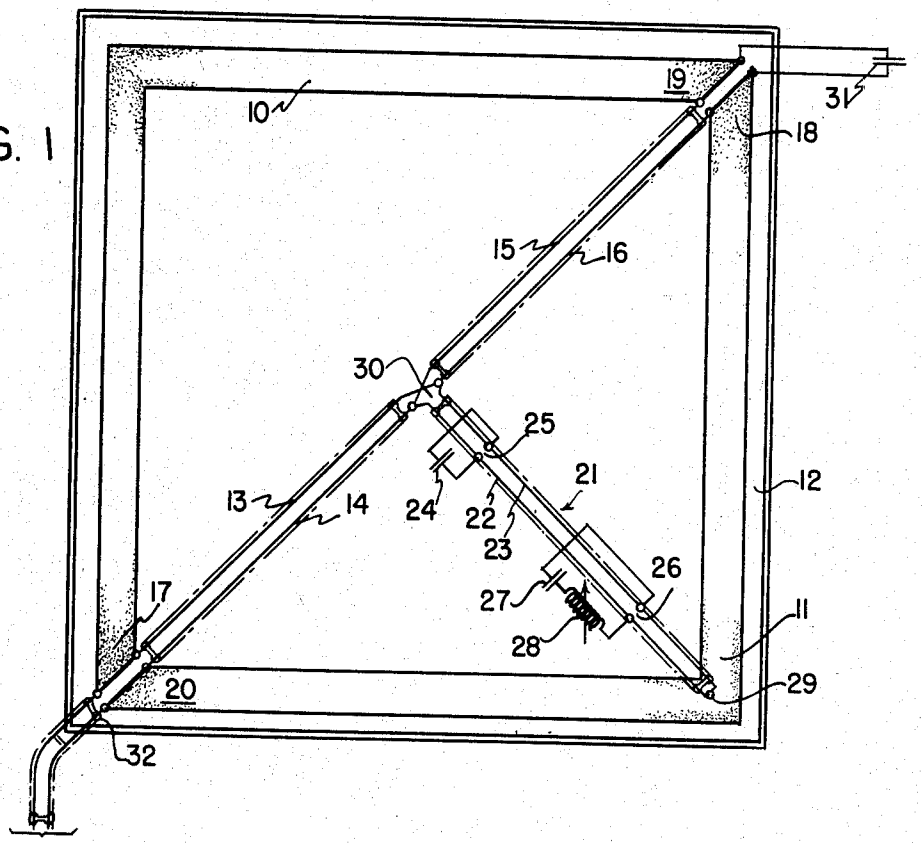
Aug. 25, 1953 K. SCHLESINGER 2,650,303

HIGH-FREQUENCY LOOP ANTENNA SYSTEM

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FIG. 1



To Receiver or Transmitter

FIG. 2

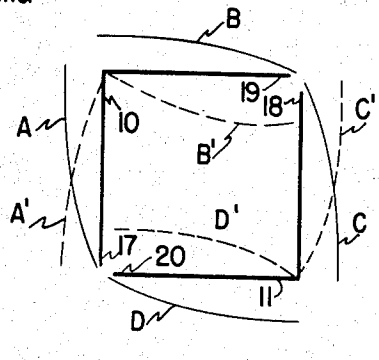
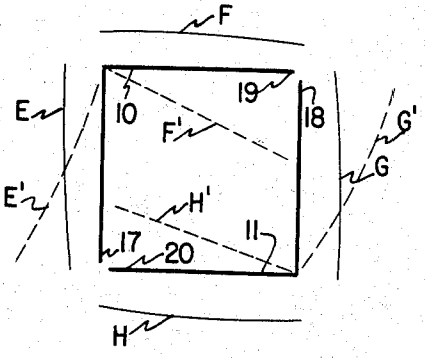


FIG. 3



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HIGH-FREQUENCY LOOP ANTENNA SYSTEM

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FIG. 4

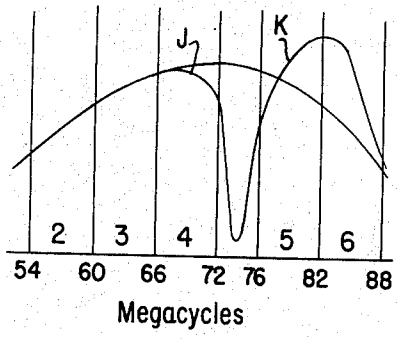


FIG. 6

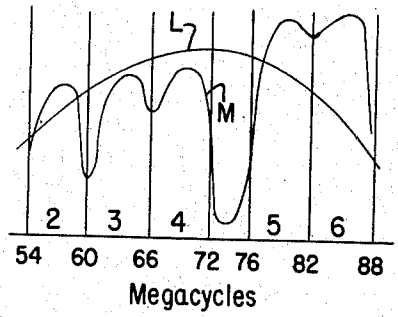


FIG. 5

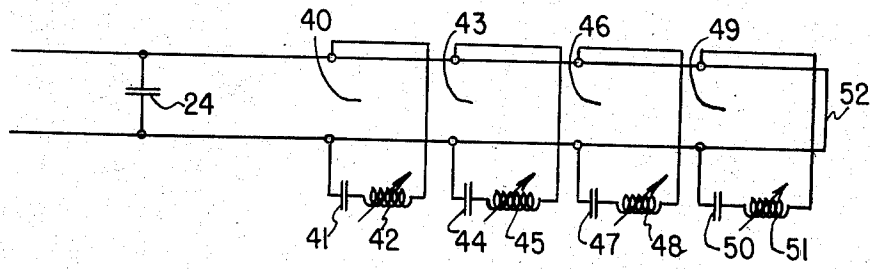
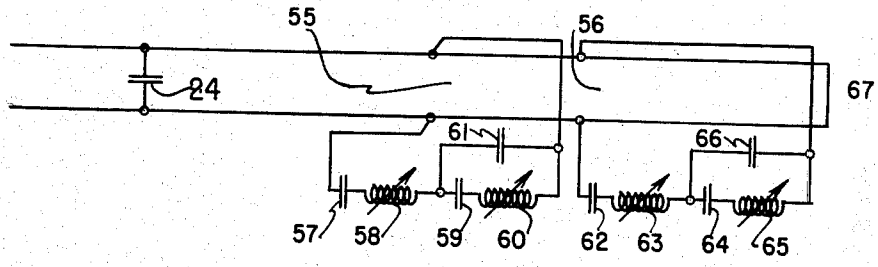


FIG. 7



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HIGH-FREQUENCY LOOP ANTENNA SYSTEM

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FIG. 8

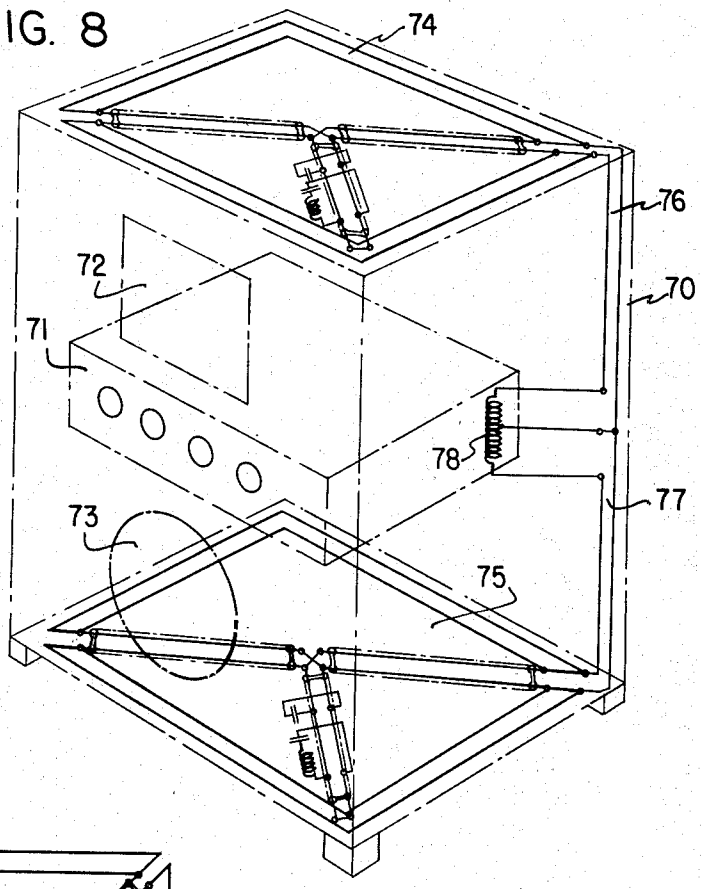
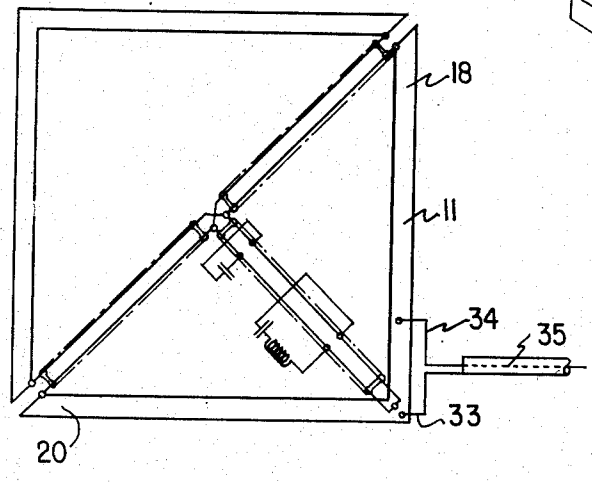


FIG. 9



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UNITED STATES PATENT OFFICE

2,650,303

HIGH-FREQUENCY LOOP ANTENNA SYSTEM

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Application July 1, 1949, Serial No. 102,612

9 Claims. (Cl. 250—33.67)

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This invention relates generally to antennas and more particularly to antennas suitable for use over a wide band of frequencies in the very high frequency range without particular tuning or orienting of the antenna for individual frequencies within the frequency range.

For the reception and transmission of radio signals in the very high frequency range, the antennas presently being used must be tuned to the frequency being used and oriented so that the pattern conforms to the direction between the communicating points to obtain the desired gain. This has caused difficulty in applications such as for television reception where a receiver may be selectively tuned to any one of a plurality of channels in a relatively wide band of frequencies and the direction from which the various signals are received differs. Presently assigned television channels are in different frequency bands generally referred to as the low band covering the frequency ranges from 54 to 72 megacycles and 76 to 88 megacycles, and the high band covering the frequency range between 174 and 216 megacycles. The low band therefore actually includes two different ranges which cover frequencies varying a large percent of the average frequency of the bands. The frequency range in the high band is still greater but is not so great when compared to the average frequency.

One commonly used practice is to provide two separate antennas, one of which is tuned for the high band and the other for the low band. In some arrangements used the two antennas can be separately oriented to provide the best directional characteristics for each band. However, this does not provide optimum orientation for each channel as stations on adjacent channels may be positioned in different directions with respect to the receiver or may be positioned so that the reflected waves which are strongest at the receiving point come from different directions. For this reason the direction must be a compromise and is not optimum for all channels in each band. Other antennas have been used which may be adjusted to provide the tuning required and which may be tuned to provide the desired orientation. However, these antennas are objectionable as it is necessary to make one or both adjustments of the antenna each time the receiver is tuned to a different channel. Such complicated adjustment is obviously undesirable, especially in connection with a receiver to be used in the home and by unskilled operators.

It is, therefore, an object of the present invention to provide an improved television antenna which can be built into a television receiver cabinet and which does not require tuning or orientation for the various television channels.

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A further object of this invention is to provide an improved television antenna having high pick-up sensitivity and which rejects sky-waves to thereby eliminate a plurality of pictures generally called ghosts.

A still further object of this invention is to provide a magnetic loop antenna which is automatically tuned to provide high response on three non-contiguous frequency ranges in the very high frequency band.

Another object of this invention is to provide an improved tuning arrangement which provides high response over various frequency channels within a wide range of frequencies.

A feature of this invention is the provision of a loop antenna system with sides having a length substantially equal to one quarter of a wave length at a relatively high frequency and tuned to provide a high response at a relatively low frequency. The antenna system so provided can easily be built into a television receiver cabinet without increasing the size thereof.

Another feature of this invention is the provision of a loop antenna system having two V-shaped sections positioned with respect to each other to form a square and a coupling system for connecting the sections together including a tuning stub to provide optimum response in a plurality of non-contiguous frequency ranges.

Still another feature of this invention is the provision of an antenna system including a plurality of tuned loop antennas coupled together to provide increased gain.

A further feature of this invention is the provision of a loop antenna formed by depositing conducting material on an insulating member with the loop having dimensions optimum for operation in a high frequency band and a tuning stub connected to the loop for providing high response in a lower frequency band.

A still further feature of this invention is the provision of an improved and simplified tuning stub which provides tuning on a plurality of channels and in which a transmission line forms certain of the inductances thereof.

Further objects and features will be apparent from a consideration of the following description taken in connection with the accompanying drawings in which:

Fig. 1 is a plan view of the loop antenna system in accordance with the invention;

Fig. 2 shows the current and voltage distribution in the antenna when operating in the high frequency band;

Fig. 3 illustrates current and voltage distribution of the antenna when operating in the low frequency band;

Fig. 4 illustrates the low frequency response of the antenna illustrated in Fig. 1;

Fig. 5 illustrates a modified tuning stub for use with the antenna in Fig. 1;

Fig. 6 illustrates the low frequency response provided by the matching stub of Fig. 5;

Fig. 7 illustrates a further embodiment of the tuning stub;

Fig. 8 illustrates the coupling of a plurality of antenna systems in accordance with the invention; and

Fig. 9 illustrates a modified manner of coupling to the antenna in accordance with the invention.

In practicing the invention, there is provided an antenna system suitable for receiving or transmitting signals on both the low and high frequency television ranges. The antenna system includes two V-shaped conducting sections which may be provided by depositing conducting material on an insulating sheet. The V-shaped sections are positioned so that the sides thereof form a square with each side having a length substantially equal to one quarter of a wave length of the highest frequency in the high frequency range. The two sections are connected in parallel by a transmission line which is transposed to connect the oppositely positioned ends of the two sections together. A tuning stub is connected to the transmission line for tuning the loop antenna to provide high response in the channels in the low frequency range. The tuning stub may include resonant circuits for emphasizing each channel in the low frequency range or may emphasize the lower and higher frequency channels in the low frequency range as separate groups. The tuning stub includes a balanced transmission line which forms certain of the electrical components of the stub. The antenna systems thus provided may be coupled to receivers in various ways, and a plurality of systems may be coupled together to provide greater response.

Referring now to the drawings, in Fig. 1, there is illustrated a loop antenna system including conducting sections 10 and 11 supported on an insulating member 12. The conducting sections 10 and 11 may be formed by depositing material on the insulating sheet 12 in a well known manner. The sections 10 and 11 are each V-shaped and are positioned so that the sides thereof form a square. The sections are connected in parallel by a transmission line including conductors 13, 14, 15 and 16. Sections of standard balanced 300 ohm transmission line are suitable for this purpose. The transmission line is transposed so that the conductors 13 and 16 are connected together to connect the end 17 of the section 10 to the end 18 of section 11. Similarly, conductors 14 and 15 are interconnected to connect the end 19 of the section 10 and the end 20 of the section 11.

Connected between the sections of the transmission line is a tuning stub 21 including conductors 22 and 23 which may also be the conductors of a balanced 300 ohm transmission line. A condenser 24 is connected across the transmission line at point 25 which is spaced along the transmission line from the junction point 30 where the stub is connected to the conductors 14 and 16. Spaced along the stub at point 26 a further distance from the said junction point 30, a tuned circuit is connected across the transmission line 21 including a condenser 27 and a variable inductor 28. Spaced still further from the junction point 30, the conductors 22 and 23 are shorted at point 29 and are connected to V-shaped sections 11. As will be more fully explained, this point on both the tuning stub and on the antenna section is at zero potential and stability is obtained by interconnecting the transmission line and the antenna section.

Each side of the V-shaped sections has a length substantially equal to one quarter of a wave at the highest frequency of the high frequency range. As the high frequency television range extends from 174 to 216 megacycles a quarter wave at the highest frequency is about 15''. This provides a high response throughout the entire high frequency range. The length of each transmission line section connecting the antenna sections to the stub, plus the length of the stub from the point 30 to the point 25 must also be substantially equal to an electrical quarter wave at the said highest frequency in the high frequency band. The transmission line conductors are effectively shorted at this point with respect to operation in the high frequency range by the condenser 24. Highly satisfactory results have been obtained by making the sides of the V-shaped sections 15 inches long, the connections from the antenna sections to the stub about 10 inches long, and the stub section between points 30 and 25 about 2 inches long. When the antenna is connected to the receiver or transmitter at points 17 and 20 as illustrated, a small capacitor 31 having a value of the order of three micromicrofarads connected to the opposite ends 18 and 19 of the sections may provide improved operation in the high frequency range.

In Fig. 2 there is illustrated the current and voltage distribution along the sections of the antenna when operating in the high frequency range. The current distribution is shown by solid lines and the voltage distribution by dotted lines. The curves extending outside the square are positive and the curves inside the square are negative. As each side is substantially one quarter wave length the current will rise from zero at point 17 to a maximum at the corner of the V-shaped section 10 as illustrated by the curve A. The current will then decrease to zero as it continues along the section 10 to the point 19 as illustrated by curve B. The current then goes from point 19 diagonally across the loop to point 20 and builds up along the section 11 as indicated by curve D. The current then decreases as it approaches the point 18 as indicated by curve C. The voltage distribution is shown by curves A', B', C' and D' and the curves indicate that the voltage is zero at the corners of the sections 10 and 11.

For operation in the low frequency range, the condenser 24 provides the main tuning of the antenna. The value of the condenser must be related to the inductance of the loop to tune the loop for operation over the desired frequency range. In selecting these values the relation of the value of the condenser to the resistance of the circuit must also be considered in order to obtain sufficient bandwidth for good response over the entire low frequency band. As presently assigned channels in the low frequency band are in two separated frequency ranges, it is possible by proper design of the tuning stub to emphasize

these desired frequencies. Such tuning is provided by the section of the transmission line between points 25 and 26, the condenser 27, the inductor 28 and the section of transmission line between points 26 and 29.

In Fig. 3 the current and voltage distribution is shown for operation in the low frequency band. As each side of the loop is only a small portion of a quarter wave in this band, the current cannot go from zero to maximum along any one side but remains substantially constant throughout the antenna. This is illustrated by the curves E, F, G and H which show the current distribution on the sections 10 and 11 respectively. The voltage distribution is shown by the curves E', F', G' and H' and is similar to that shown in Fig. 2 for high frequency operation except the voltages vary substantially linearly instead of sinusoidally. The voltage at the corners of the V-shaped sections remains at zero.

As previously stated, the matching stub 21 tunes the antenna for maximum response in the low frequency range. As previously stated, the antenna sections are connected in parallel. The condenser 24 is selected to have a value to resonate with the inductance of the antenna sections at a frequency of the order of 50 megacycles which is just below the lowest frequency to be received. The inductance of the antenna sections can be controlled by controlling the width thereof and sections about 1'' wide provide an inductance of approximately 1 microhenry which is a satisfactory value. The condenser 24 must, in addition to properly tuning the antenna sections, also be so related to the resistance of the load to provide the required band width which in this case is about thirty five megacycles. For a load resistance of 300 ohms which is desirable for television use, the condenser 24 must have a value of the order of 15 micromicrofarads and this provides the proper band width in a system as has been described in connection with Fig. 1. The condenser 24 therefore effectively shorts the stub 21 at point 25 with respect to operation in the high frequency range. It is to be pointed out that the effective value of this condenser at the antenna is much less, being of the order of 5 micromicrofarads, and the impedance at various points in the system varies, being of the order of 1200 ohms at the point 30. These values have been found to provide the proper tuning and also the necessary band width.

In Fig. 4 there is illustrated the response curve of the antenna of Fig. 1 in the low frequency range. The curve J indicates the response provided by the main tuning condenser 24. By use of the tuning stub as illustrated in Fig. 1, however, the channels in the frequency range from 66 to 88 megacycles can be increased as indicated by the curve K. This is provided by a tuned trap circuit having a pole in the unused portion of the frequency range between 72 and 76 megacycles. The trap circuit is tuned to 77 megacycles and the pole appears at 74 megacycles. The effect of this circuit is to decrease the response in the range between 72 and 76 megacycles which is not used and increase the response in the range between 76 and 88 megacycles to provide improved response at these channels. The values of the circuit elements to provide such a trap at this frequency are impractical for commercial application but by use of scaling inductances the circuit can be given a practical form. The scaling inductances are provided by the section of the transmission line 21 between

points 25 and 26 which in effect provides inductances in series with the condenser 27 and inductor 28. The spacing between points 25 and 26 is about 5½ inches when 300 ohm balanced line is used. The trap circuit is completed by the section of the transmission line between points 26 and 29 which form an inductance in shunt with the condenser 27 of the inductor 28. This section is about 2½ inches long.

Connections can be made to the loop antenna system at various points depending upon the impedance desired. The impedance increases from a minimum at the corners of the V-shaped sections becoming greater along the sides of the V's and being a maximum at the point 30 where the conductors 13—16 and 14—15 are connected to the stub 21. The impedance at the adjacent ends of the section, that is, at 17 and 20 or at 18 and 19 has been found to be approximately 300 ohms and therefore connection can be made to the antenna at these points by standard 300 ohms balanced transmission line. This is illustrated by the lead-in line 32. Fig. 9 illustrates the connection of an unbalanced coaxial line 35 to the antenna system with the shield 33 connected to the corner or zero voltage point of the section 11 and the center conductor connected to the section about one third of the way to the end 18.

In Fig. 5 there is illustrated a modified tuning stub which includes in addition to the main condenser 24 a large number of tuning elements connected to various points along the transmission line. At point 40 there is connected a series circuit including condenser 41 and inductor 42. Similarly at points 43, 46 and 49, series circuits including the condenser-inductor combinations 44—45, 47—48, and 50—51 are provided. The transmission line is shorted at point 52. In this arrangement the circuits at the points 40, 43, 46 and 49 form traps which act as a shorting bar at the frequency to which they are tuned. The trap at point 40 will be tuned to the highest frequency and the traps at 43, 46 and 49 to the lower frequencies in order. Above its frequency each trap acts as an inductive load and below its frequency it acts as a capacitive load. The effective length of the stub to each trap, considering the loading of the other traps must be such to provide tuning at the desired frequency if a shorting bar was used. The shorted end point 52 provides tuning at the lowest frequency involved. Such a matching stub will provide tuning at each of the five channels in the low frequency range. This is illustrated in Fig. 6 in which the curve L shows the response provided by the main tuning condenser 24 and the curve M shows the modified response obtained by using the stub as illustrated in Fig. 5.

Instead of providing a tuning stub having a separate circuit for tuning to each frequency in the low frequency band, it is possible to use a stub having double tuned circuits. This is illustrated in Fig. 7 in which the stub includes double tuned circuits connected at points 55 and 56. Each of these circuits is resonant at two points and is generally equivalent to two separate circuits as illustrated in Fig. 5. More specifically, the circuit connected at point 55 includes capacitor 57, inductor 58, capacitor 59 and inductor 60, all of which are connected in series, and capacitor 61 which is bridged across the capacitor 59 and inductor 60. This circuit may be tuned to resonate the antenna on channels 5 and 6 in the frequency range from 76 to 88 megacycles. The resonant circuit connected at point 56 includes

capacitor 62, inductor 63, capacitor 64 and inductor 65, all connected in series, and the capacitor 66 bridging capacitor 64 and inductor 65. This circuit may resonate at channels 3 and 4 in the frequency range from 60 to 72 megacycles. The shorted end 67 of the stub can be chosen to provide tuning at channel 2 from 54 to 60 megacycles. The response obtained by the circuit illustrated in Fig. 7 is almost exactly the same as that obtained by the circuit in Fig. 5 and as illustrated in Fig. 6.

The antenna system as described above requires only a very thin sheet about 16" square for the entire structure. As stated above, the antenna can be constructed by depositing conducting material on an insulated sheet. The transmission lines are flat and require very little space and the separate tuning elements required are all of very small size. It is obvious from this that the antenna can be placed inside a cabinet housing a television receiver or the like. As the antenna has a completely circular pattern, the receiver can be positioned in any desired direction without effecting the pick-up of the antenna. The antenna must be supported in a horizontal plane and accordingly, can easily be mounted on the top wall of a receiver cabinet.

Increased signal response can be obtained by using a plurality of antenna systems in accordance with the invention. It has been found that in order to obtain substantially increased gain it is necessary that the antennas be spaced at least one foot part. Such an antenna structure can be provided as a unit separate from a receiver or may be built into a console type receiver. This is illustrated in Fig. 8 in which a cabinet 70 for a console receiver is shown in outline. The receiver may include a chassis 71, picture tube 72 and loudspeaker 73. The arrangement of these components in the cabinet is merely illustrative and various other arrangements can obviously be used. An antenna system as illustrated in Fig. 1 is indicated at 74 at the top of the cabinet and a second such antenna system is indicated at 75 at the bottom of the receiver. These antennas can be separated by a distance of two feet or more in the usual console type cabinet. Each antenna system 74 and 75 is complete in itself with the systems being connected by lead-ins 76 and 77 which may be 150 ohm balanced transmission line. The two transmission lines are then connected in series to the input of the television receiver circuit to provide a 300 ohm impedance. It is common practice to provide an antenna coupling circuit in television receivers which permits the connection of either a balanced or an unbalanced lead-in line. This may be accomplished by using a transformer winding having a center tap as illustrated at 78. For connecting the antenna systems 74 and 75 to such a circuit, each lead-in may be connected across one section of the input winding so that the lead-ins are not only in series but the center point thereof is coupled to the input of the receiver. This method of coupling is illustrative and other coupling methods may be used.

It is seen from the above that there is provided an improved antenna system including a magnetic antenna having a circular pattern and which is automatically tuned for all desired television frequencies. It is obvious that the antenna system disclosed may be provided in various embodiments suitable for either indoor or outdoor use. The sections of the antenna may take other configurations than the V-shape illustrated and need not be limited to two sections as disclosed. The antenna provides good pick-up sensitivity and rejects sky waves so that a plurality of images will not be formed to produce the effect generally referred to as ghosts.

The magnetic antenna system disclosed is particularly adaptable for inside use since it is small and since the pattern is circular so that the direction of the antenna is not important. In tests made there are no dead angles in the horizontal plane at which the response of the antenna is reduced. By using a plurality of antenna systems coupled together the overall gain of the antenna may be substantially increased. The use of two antenna systems as disclosed in a console receiver will provide improvement of the order of 50% over that of a single antenna system.

While certain embodiments of the invention have been disclosed which are illustrative thereof, it is obvious that various changes and modifications can be made therein without departing from the intended scope of the invention as defined in the appended claims.

I claim:

1. A loop antenna system for operation in two separate relatively widely spaced frequency ranges comprising, a pair of V-shaped conductors having low inductance and positioned to form a square, each of the sides of said conductors having a length substantially equal to one quarter wave length at the highest frequency of the higher frequency range to provide antenna elements having a natural response in said higher frequency range, a balanced transmission line connected to the ends of said V-shaped conductors with the conductors of said transmission line being transposed, tuning means connected to said transmission line including condenser means for tuning said antenna system across the lower of said frequency ranges, said tuning means also including a resonant circuit for emphasizing the response of the higher frequencies in said lower frequency range.

2. A loop antenna system for operation in two separate non-contiguous relatively wide frequency ranges comprising, a sheet of insulating material, conducting material on said sheet providing two V-shaped low inductance conductors positioned to form a square, each of the sides of said conductors having a length substantially equal to one quarter wave length at the highest frequency of the higher frequency range so that said antenna system has a natural response in said higher frequency range, a balanced transmission line connected to the ends of said V-shaped conductors with the conductors of said transmission line being transposed, a tuning stub connected to said transmission line including means for tuning said antenna system across the lower of said frequency ranges, said tuning stub also including resonant means for emphasizing the response of the higher frequencies in said lower frequency range, said resonant means having high impedance at all frequencies above the resonant frequency thereof and having substantially no effect on said antenna system in said higher frequency range.

3. A loop antenna system for operation in two separate relatively widely spaced frequency ranges comprising, a pair of V-shaped conductors having low inductance and positioned to form a square, each of the sides of said conductors having a length substantially equal to one quarter wave length at the highest frequency of

the higher frequency range, a balanced transmission line connected to the ends of said V-shaped conductors with the conductors of said transmission line being transposed, a tuning stub connected to said transmission line for tuning said antenna system to the lower of said frequency ranges, said tuning stub including a trap circuit resonant within the lower frequency range for emphasizing the response of the higher frequencies in said lower frequency range, said trap circuit presenting high impedance at all frequencies above said lower frequency range.

4. A loop antenna system for operation in three separate non-contiguous frequency ranges comprising two V-shaped conductors having low inductance and positioned to form a square, each of the sides of said conductors having a length substantially equal to one quarter wave length in the highest frequency range, a balanced two conductor transmission line connected to the ends of said V-shaped conductors with the conductors of said transmission line being transposed, a tuning stub connected to said transmission line including a capacitor having the value required for tuning said antenna system across the two lower frequency ranges, said tuning stud including a resonant circuit for emphasizing the response of the intermediate range of said three frequency ranges, said resonant circuit having a high impedance in said highest frequency range.

5. A loop antenna system for operation in three separate non-contiguous frequency ranges comprising two V-shaped conductors having low inductance and positioned to form a square, each of the sides of said conductors having a length substantially equal to one quarter wave length in the highest frequency range, a balanced two conductor transmission line connected to the ends of said V-shaped conductors, a tuning stub connected to said transmission line including a capacitor having the value required for tuning said antenna system across the two lower frequency ranges, said tuning stub including a trap circuit for reducing the response of said antenna system at frequencies between said two lower frequency ranges and for emphasizing the response of the intermediate range of said three frequency ranges, said trap circuit having a high impedance at frequencies in said highest frequency range.

6. A loop antenna system for operating in two separate relatively widely spaced frequency ranges comprising, a pair of antennas each including first and second V-shaped conductors having low inductance, said conductors being positioned in the form of a square, each of the sides of said conductors having a length substantially equal to one quarter wave length in the higher frequency range, circuit means connected to the ends of said V-shaped conductors for connecting said conductors in parallel, and tuning means connected to said circuit means for tuning said antenna for operation in said lower range of frequencies, said tuning means including a trap circuit resonant within the lower frequency range for emphasizing the response of the higher frequencies in said lower frequency range, and lead-in lines for each of said antennas individually connected to the adjacent ends of said V-shaped conductors, said lead-in lines being connected in series for coupling said antennas together.

7. A loop antenna system for operation in two separate relatively widely spaced frequency ranges including in combination, first and second elongated conductor portions having relatively

low inductance and each having a length substantially equal to one-half wavelength in the higher of said frequency ranges, said conductor portions being shaped and positioned to form a loop with the ends of each portion being adjacent the ends of the other, a balanced two-conductor transmission line connected at each end to the adjacent ends of said conductor portions, the conductors of said transmission line being transposed so that said conductor portions are connected in parallel, a two-conductor stub connected to the conductors of said transmission line at the center point thereof, condenser means bridging the conductors of said stub at a predetermined point thereon for tuning said parallel connected conductor portions for operation in the lower frequency range, said condenser means effectively short-circuiting said stub in said higher frequency range, the length of said stub from said point to the connection thereof to said transmission line and the length of said transmission line from the center point thereof to either end together being substantially equal to one-quarter wavelength in said higher frequency range to thereby form shorted quarterwave stubs connecting said conductor portions in said higher frequency range.

8. A loop antenna system for operation in two separate relatively widely spaced frequency ranges including in combination, first and second elongated conductor portions having relatively low inductance and each having a length substantially equal to one-half wavelength in the higher of said frequency ranges, said conductor portions being shaped and positioned to form a loop with the two ends of one portion being individually adjacent the ends of the other, balanced two-conductor transmission line means connected at each end to the adjacent ends of said conductor portions, said transmission line means including transposed conductors for connecting said conductor portions in parallel, and tuning means bridging the conductors of said transmission line means at a predetermined point thereon for tuning said parallel connected conductor portions for operation in the lower frequency range, said tuning means effectively short-circuiting said transmission line means at said predetermined point in said higher frequency range, the effective length of said transmission line means from said predetermined point to either of the ends thereof connected to said conductor portions being substantially equal to one-quarter wavelength in said higher frequency range to thereby form shorted quarterwave stubs interconnecting said halfwave conductor portions for operation in said higher frequency range.

9. In a television receiver including a chassis and a cabinet for housing the chassis and other operating components of the receiver, a loop antenna system for operation in two separate relatively widely spaced frequency ranges including in combination, a pair of antennas supported in said cabinet in horizontal positions in spaced relation with respect to each other, each of said antennas including first and second elongated conductor portions having relatively low inductance and each having a length substantially equal to one-half wavelength in the higher of said frequency ranges, said conductor portions of each antenna being shaped and positioned to form a loop with the two ends of one portion being individually adjacent the ends of the other, balanced two-conductor transmission line means connected at each end to the adjacent ends of

said conductor portions, said transmission line means including transposed conductors for connecting said conductor portions in parallel, and tuning means bridging the conductors of said transmission line means at a predetermined point thereon for tuning said parallel connected conductor portions for operation in the lower frequency range, said tuning means effectively short-circuiting said transmission line means at said predetermined point in said higher frequency range, the effective length of said transmission line means from said predetermined point to either of the ends thereof connected to said conductor portions being substantially equal to one-quarter wavelength in said higher frequency range to thereby form shorted quarterwave stubs interconnecting said halfwave conductor portions for operation in said higher frequency range and

head-in means for said antenna system connected to adjacent ends of said conductor portions of each of said antennas and to the receiver chassis.

KURT SCHLESINGER.

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