

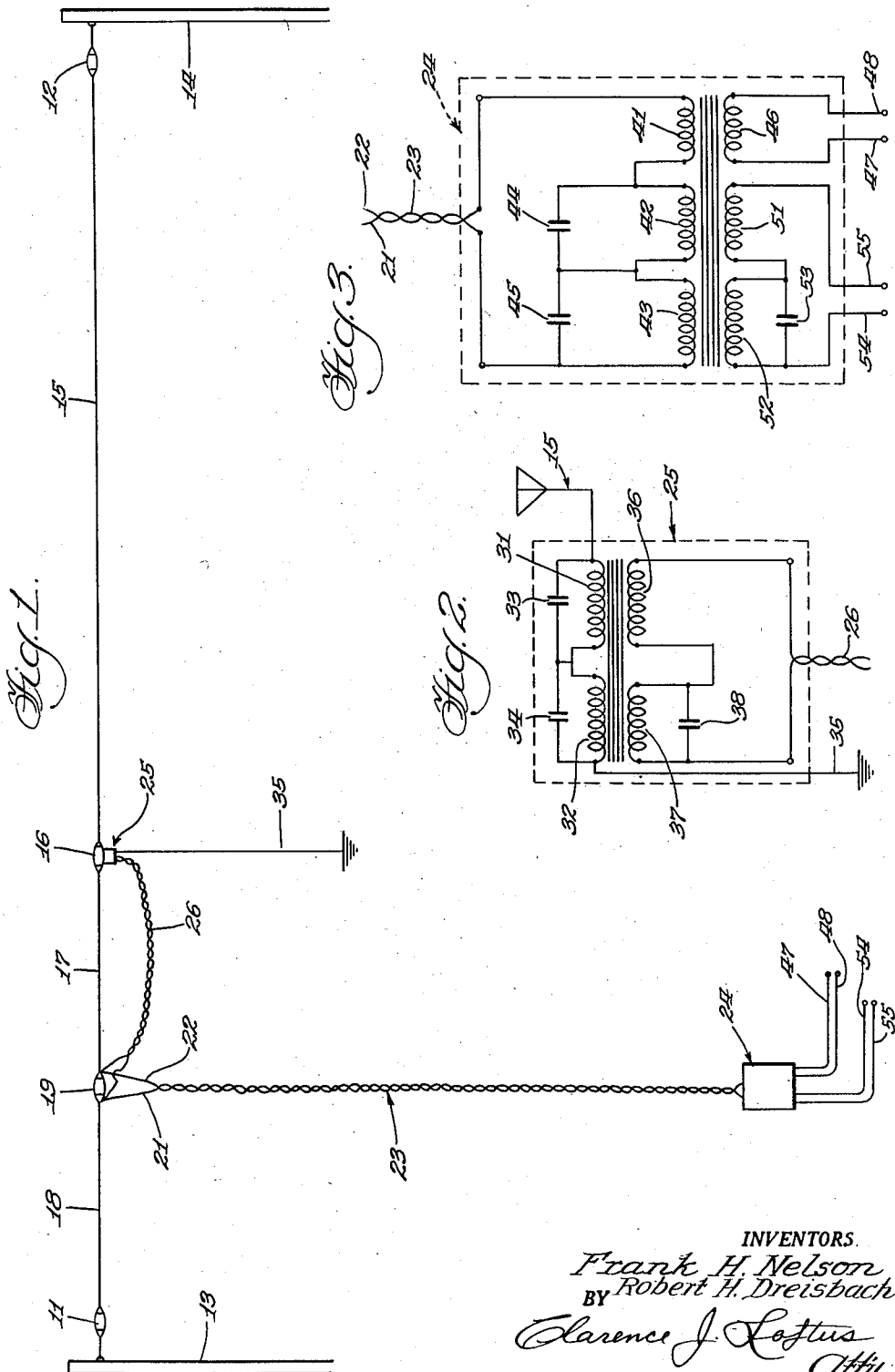
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F. H. NELSON ET AL

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AMPLITUDE MODULATION-FREQUENCY MODULATION ANTENNA

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INVENTORS.
Frank H. Nelson
BY *Robert H. Dreisbach*
Clarence J. Loftus
Atty.

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AMPLITUDE-MODULATION—FREQUENCY-MODULATION ANTENNA

Frank H. Nelson, Philadelphia, Pa., and Robert H. Dreisbach, Fort Wayne, Ind., assignors to The Magnavox Company, Fort Wayne, Ind., a corporation of Delaware

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It has long been common practice to provide commercially manufactured radio receiving sets capable of reception of signals in several widely spaced wave bands, as, for example, the frequency modulation band of 88 to 108 megacycles, a short wave band of 4 to 18 megacycles, as well as the standard broadcast band of 550 to 1600 kilocycles. These sets are ordinarily provided with a wave band switch whereby separate tuning circuits are used for reception of the different frequencies. The potential usefulness of the multiple band sets has heretofore been greatly limited by the antenna requirements, however, since it is well known that no conventional antenna will respond satisfactorily to frequencies in these three widely spaced bands. It has therefore been necessary to provide each receiver of this type with two or more antennas, each with a separate lead-in and a switching arrangement to selectively connect the tuning circuits of the receiver to any one of the antennas in order to get efficient reception over all wave bands covered.

It is the general aim of the present invention to provide an antenna system having but one lead-in, so that no antenna switching is necessary, yet capable of high gain performance on each of several different wave bands of widely varying frequency. The accomplishment of this general aim involves several aspects. One advantage is the elimination of the switching heretofore required. Another is the simplification of the system by the use of one lead-in for all of the bands. The reduction of noise due to lead-in interference is a further consideration. Also, it is important to attain the desired performance by an antenna that is simple, inexpensive, and adapted to easy installation; even by persons having little mechanical skill and no knowledge of electronics. Most important, however, is the necessity of providing an antenna system wherein wanted signal frequencies in any of the bands are transmitted to the receiver without serious losses, yet wherein unwanted signals are effectively suppressed.

It is therefore a primary object of the present invention to accomplish these aims by the provision of an antenna system comprising a dipole section resonant in the range of the highest frequencies to be received (that is, the FM band) and a straight wire antenna suited to reception of the short wave and broadcast signals; with only one lead-in, which consists of a transmission line extending to a transformer at the receiver set. The accomplishment of this ob-

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ject also avoids the need of antenna switching arrangements. A further object of the invention is to accomplish these functional results by the provision of an antenna of simple and inexpensive physical structure, designed to be unobtrusive in appearance, strong and durable, yet so constructed that it may be easily installed in almost any desired location, even by persons untrained in electronics or the mechanical arts.

According to these teachings these objects are accomplished by a system which includes means to isolate the dipole from the straight section during FM reception, so that signal energy received on the dipole will not be dissipated but will be fed to the receiver without substantial losses. Also, means are provided to suppress high frequency signals that may be imposed on the straight section of the system so that interference will not result, yet to transmit lower frequency signals from this section to the lead-in without substantial losses. These functions are accomplished in the present teaching by the provision of a novel antenna transformer having two primary sections tuned to the broadcast and short wave bands respectively, together with a secondary connected to the lead-in through an isolation transformer consisting of a length of transmission line so related to the impedance of the antenna transformer secondary as to present an extremely high impedance value at the point of connection between the dipole and lead-in. It follows that substantially all of the signal energy received on the dipole will be fed through the lead-in to the set.

A present preferred embodiment of the invention is illustrated in the drawings of this disclosure wherein:

Figure 1 is a diagrammatic view of an antenna system as here contemplated;

Figure 2 is a schematic diagram of the antenna transformer utilized in the system of Figure 1; and

Figure 3 is a schematic diagram of the receiver transformer as here contemplated.

As shown, the structure consists of a relatively long span of wire extending between the insulators 11 and 12 which may be secured to any supporting surfaces represented by the masts 13 and 14. The span of wire between these two insulators is not continuous in an electrical sense but consists of a relatively long straight wire section 15 extending from the insulator 12 to an intermediate insulator 16 and a dipole section comprising elements 17 and 18 separated by a spacing insulator 19. The inner ends of the

dipole elements 17 and 18 are directly connected to the paired conductors 21 and 22 of the lead-in generally designated as 23 which extends to a receiver transformer 24. The straight section 15 of the system, which functions to receive broadcast and short wave signals, is inductively coupled to the lead-in 23 through an antenna transformer 25 and an isolation transformer 26 which may consist of a predetermined length of dual conductor transmission line joined to the inner ends of the dipole elements 17 and 18 at their point of connection with the lead-in conductors 21 and 22.

The antenna transformer 25 may be physically mounted within the insulator 16. Its circuit is preferably arranged according to the schematic circuit diagram of Figure 2. The straight wire section 15 of the system feeds directly to a transformer primary winding consisting of two differently tuned sections 31 and 32, bridged by the condensers 33 and 34 respectively. The circuit 31—33 is tuned to the short wave band and the section 32—34 is tuned to the broadcast band. The circuit from the straight wire section 15 of the antenna system extends through these sections in series and thence to ground by way of the conductor 35.

The secondary winding of the antenna transformer consists of two separate sections 36 and 37, corresponding to the sections 31 and 32 of the primary winding and similarly tuned. The winding 37 is bridged by capacitor 38, and the sections 36 and 37 are connected in series with each other. They are also connected through the length of transmission line 26 to the lead-in at the point of connection between the lead-in and the inner ends of the dipole sections.

The receiver transformer, generally designated at 24 has windings as schematically shown in Figure 3. The primary winding comprises three sections 41, 42 and 43 in series. The sections 42 and 43 are bridged by capacitors 44 and 45 respectively. The values of inductance and capacitance are such that the sections 41, 42 and 43 are tuned to the FM band, short wave band, and broadcast band respectively. This transformer includes two secondary windings. The winding 46 is tuned to the FM band and has leads extending directly to output terminals 47 and 48. The other secondary winding comprises a section 51 tuned to the short wave band, in series with a section 52 bridged by the capacitor 53 and tuned within the frequency range of the broadcast band. These windings are connected to the output terminals 54 and 55 which lead to the tuning circuits of the AM and short wave receiver. If desired, one of these output terminals may be grounded so that the lead-in circuit, which is balanced from the antenna transformer 25 to the receiver transformer 24, is converted to an unbalanced line for feeding the receiver.

Operation

The operation of the system is as follows: When signals of standard broadcast frequencies are being received the signals will be impressed on the long straight wire section 15 and will thence be fed through the sections 31 and 32 of the antenna transformer primary and to ground. The field set up by passage of the signal current through the winding 32 of the transformer primary will induce a corresponding signal in the secondary 37. The signal is fed through the isolation section 26 of the transmission line to the

lead-in 23 and thence to the receiver transformer 24. At short wave and broadcast frequencies the dipole elements 17 and 18 have negligible effect on the characteristics of the transmission line, so that the lead-in 23 and isolation portion 26 function only as a continuous balanced line through which the signal is transmitted from the antenna transformer 25 to the receiver transformer 24. At the receiver transformer the signal is fed through the primary and induced into the secondary through the sections 43 and 52 which are tuned to the broadcast frequency. The signal thus appears at the output terminals 54 and 55 leading to the receiver.

When receiving signals in the short wave band, the system functions in the same manner as described above with the exception that the coupling in the antenna transformer 25 is accomplished primarily between the windings 31 and 36, which are tuned to the short wave band. Similarly, in the receiving transformer 24 the coupling is accomplished primarily in the central sections 42 and 51 of the primary and secondary windings.

In receiving a frequency modulation signal (that is, a signal in the 88 to 108 megacycle band), any signal appearing on the straight section 15 of the antenna will be suppressed, since the primary windings 31 and 32 of the antenna transformer will function as an effective radio frequency choke. This is effective to minimize any possibility of mutual coupling between the straight section 15 of the antenna and dipole elements as well as to reduce the energy transfer in the transformer to a negligible value.

The dipole elements 17 and 18 will respond to the FM signal, however, so that the signal energy appears as a current source across the insulator 19. By viewing Figure 1 of the drawing it will be seen that there are two possible paths for current flowing from this source. One path is through the lead-in 23 and primary of the receiver transformer 24. The other path is through the section 26 of the transmission line and through the secondary windings of the antenna transformer 25. By the teachings of this invention the input impedance values of these two paths are so related that the path to the antenna transformer presents an extremely high impedance, far above the input impedance presented by the lead-in. Thus substantially all of the signal energy is fed down the lead-in to the receiver transformer and thence to the set.

It is a known phenomenon that a quarter-wave section of lossless transmission line, when short-circuited, presents an infinite impedance to a signal imposed upon it, and that odd multiples of such a quarter-wave section exhibit similar characteristics. When the line is not short-circuited, but is terminated by an impedance Z_R the input impedance Z_S in a lossless line may be designated by the following formula, when the characteristic impedance is R_c , its length S , and phase constant B .

$$Z = R_c \frac{Z_R + jR_c \tan BS}{R_c + jZ_R \tan BS}$$

In the present invention this formula is utilized by designing the antenna transformer 26 so that the length of the isolation section S of the transmission line and the impedance Z_R of the transformer winding combine to present an extremely high input impedance to this current path when viewed from the separating insulator 19 at the junction of the dipole sections and the

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lead-in. Thus this branch of the circuit may be said to have an electrical length substantially equal to an odd quarter wave section of transmission line, and to present an extremely high impedance to any signal appearing on the dipole.

It is a known theorem that a current imposed on parallel impedances will divide itself in a manner inversely proportional to absolute magnitude of each of them. Thus the possible path of current flow through the isolation section 26 will present an impedance greatly exceeding the impedance presented by the lead-in to the receiver transformer. It follows that substantially all of the signal energy will flow through the lead-in to the receiver transformer and will be induced from the primary section 41 into the secondary winding 46 so that the signal will appear at the output terminals 47 and 48.

From the foregoing it is believed apparent that the teachings of this invention accomplish the intended aims and objects, since an antenna according to the present disclosure is capable of high gain performance in the standard broadcast band, short wave band and in the frequency modulation band, yet these signals are received without interference between the different sections of the antenna and are fed to the receiver through a common lead-in so that no antenna switching is required. The system inherently suppresses noise due to stray voltages induced in the lead-in section, since any noise voltages induced therein will be equal in magnitude and in phase in the two conductors of the line. Thus these voltages will appear in the transformer windings in phase opposition, and will result in zero noise current.

An antenna according to these teachings is extremely simple in its physical structure and may be manufactured easily and economically. Moreover, it may be conveniently installed in almost any location, since it is only necessary to suspend the opposite insulators 11 and 12 between any supports conveniently available. Obviously the installation requires no technical knowledge, but may be made by anyone, even though not skilled in the mechanical or electrical arts. In short, the teachings of the present invention offer a simple, feasible and economically practical solution for a problem that has defied other attempts at solution throughout a period of years, despite a long felt and universally recognized need.

Having thus described the invention, what we claim as new and desire to protect by United States Letters Patent is:

1. An antenna system comprising, in combination, a single wire adapted to be suspended between a pair of insulators, with additional insulators dividing it into two aligned sections comprising a dipole section and an unbalanced straight wire section of length greatly exceeding the length of the dipole section and responsive to lower frequencies than the dipole section; a lead-in consisting of a dual lead transmission line coupled to said dipole section; an antenna transformer having a primary winding comprising two differently tuned sections in the circuit of the straight wire section and a secondary winding comprising two differently tuned sections; and an isolation transformer consisting of a section of dual lead transmission line coupled between said secondary winding of the antenna transformer and the dipole elements; with the input impedance of said section of transmission line and secondary of the antenna transformer

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greatly exceeding the input impedance of the lead-in.

2. An antenna system comprising, in combination, a single wire adapted to be suspended between a pair of insulators, with additional insulators dividing it into two aligned sections comprising a dipole section and an unbalanced straight wire section of length greatly exceeding the length of the dipole section and responsive to lower frequencies than the dipole section; a lead-in consisting of a dual lead transmission line coupled to said dipole section; an antenna transformer having a primary winding comprising two differently tuned sections in the circuit of the straight wire section and a secondary winding comprising two differently tuned sections; and an isolation transformer consisting of a section of dual lead transmission line coupled between said secondary winding of the antenna transformer and the dipole elements; with the total electrical length of the said section of transmission line and antenna transformer secondary substantially equal to an odd multiple of a quarter wave length of the resonant frequency of the dipole section.

3. An antenna system comprising, in combination, a single wire adapted to be suspended between a pair of insulators, with additional insulators dividing it into two aligned sections comprising a dipole section and an unbalanced straight wire section of length greatly exceeding the length of the dipole section and responsive to lower frequencies than the dipole section; a lead-in consisting of a dual lead transmission line coupled to said dipole section; an antenna transformer having a primary winding in the circuit of the straight wire section and a secondary winding; and an isolation transformer consisting of a section of dual lead transmission line coupled between said secondary winding of the antenna transformer and the dipole elements; with the input impedance of said section of transmission line and secondary of the antenna transformer greatly exceeding the input impedance of the lead-in.

4. An antenna system comprising, in combination, a single wire adapted to be suspended between a pair of insulators, with additional insulators dividing it into two aligned sections comprising a dipole section and an unbalanced straight wire section of length greatly exceeding the length of the dipole section and responsive to lower frequencies than the dipole section; a lead-in consisting of a dual lead transmission line coupled to said dipole section; an antenna transformer having a primary winding in the circuit of the straight wire section and a secondary winding; and an isolation transformer consisting of a section of dual lead transmission line coupled between said secondary winding of the antenna transformer and the dipole elements; with the total electrical length of the said section of transmission line and antenna transformer secondary substantially equal to an odd multiple of a quarter wave length of the resonant frequency of the dipole section.

5. An antenna system comprising, in combination, a dipole section; an unbalanced straight wire section of length greatly exceeding the length of the dipole section and responsive to lower frequencies than the dipole section; a lead-in consisting of a dual lead transmission line coupled to said dipole section; an antenna transformer having a primary winding in the circuit of the straight wire section and a secondary

winding; and an isolation transformer consisting of a section of dual lead transmission line coupled between said secondary winding of the antenna transformer and the dipole elements; with the input impedance of said section of transmission line and secondary of the antenna transformer greatly exceeding the input impedance of the lead-in, the total electrical length of the said section of transmission line and antenna transformer secondary being substantially equal to an odd multiple of a quarter wave length of the resonant frequency of the dipole section.

6. An antenna system comprising, in combination, a single wire adapted to be suspended between a pair of insulators, with additional insulators dividing it into two aligned sections comprising a dipole section balanced to ground and resonant to a frequency within the 88 to 108 megacycle FM band and an unbalanced straight wire section of length greatly exceeding the length of the dipole section and responsive to lower frequencies than said dipole sections; a lead-in consisting of a dual lead transmission line coupled to said dipole section; an antenna transformer having a primary winding comprising two differently tuned sections in the circuit of the straight wire section and a secondary winding comprising two differently tuned sections; and an isolation transformer consisting of a section of dual lead transmission line coupled between said secondary winding of the antenna transformer and the dipole elements; and a receiver transformer having a primary winding coupled to said lead-in and consisting of three differently tuned sections and two secondary windings, one of which consists of two differently tuned sections.

7. An antenna system comprising, in combination, a single wire adapted to be suspended between a pair of insulators, with additional insulators dividing it into two aligned sections comprising a dipole section balanced to ground and an unbalanced straight wire section of length greatly exceeding the length of the dipole section and responsive to lower frequencies than said dipole section; a lead-in consisting of a dual lead transmission line coupled to said dipole section; an antenna transformer having a primary winding comprising two differently tuned sections in the circuit of the straight wire section and a secondary winding comprising two differently tuned sections; and an isolation transformer consisting of a section of dual lead transmission line coupled between said secondary winding of the antenna transformer and the dipole elements; and a receiver transformer having a primary winding coupled to said lead-in and consisting of three differently tuned sections and two sec-

ondary windings, one of which consists of two differently tuned sections.

8. An antenna system comprising, in combination, a single wire adapted to be suspended between a pair of insulators, with additional insulators dividing it into two aligned sections comprising a dipole section balanced to ground and an unbalanced straight wire section of length greatly exceeding the length of the dipole section and responsive to lower frequencies than said dipole section; a lead-in consisting of a dual lead transmission line coupled to said dipole section; an antenna transformer having a primary winding in the circuit of the straight wire section and a secondary winding and an isolation transformer consisting of a section of dual lead transmission line coupled between said secondary winding of the antenna transformer and the dipole elements; and a receiver transformer coupled to said lead-in and having a primary winding and secondary winding.

9. An antenna system comprising, in combination, a dipole section; an unbalanced straight wire section of length greatly exceeding the length of the dipole section and responsive to lower frequencies than the dipole section; a lead-in consisting of a dual lead transmission line directly connected to the dipole section; a receiver transformer having a primary winding connected directly across the leads of the transmission line; an antenna transformer having a primary winding in the circuit of the straight wire section and a secondary winding; and an isolation transformer consisting of a section of dual lead transmission line coupling the secondary winding of the antenna transformer to the point of connection between the dipole elements and the lead-in; with the input impedance of said section of transmission line and secondary of the antenna transformer greatly exceeding the input impedance of the lead-in and receiver transformer.

FRANK H. NELSON.
ROBERT H. DREISBACH.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
Re. 19,854	Amy et al.	Feb. 13, 1936
2,021,734	Macalpine	Nov. 19, 1935
2,074,896	Earnshaw	Mar. 23, 1937
2,117,154	Dome	May 10, 1938
2,143,159	Lundahl	Jan. 10, 1939
2,189,309	Carlson	Feb. 6, 1940
2,222,406	Crossley	Nov. 19, 1940