Dec. 26, 1939. A. B. BAILEY 2,184,729

ANTENNA SYSTEM

Filed April 15, 1937 2 Sheets-Sheet 1

FIG. 1

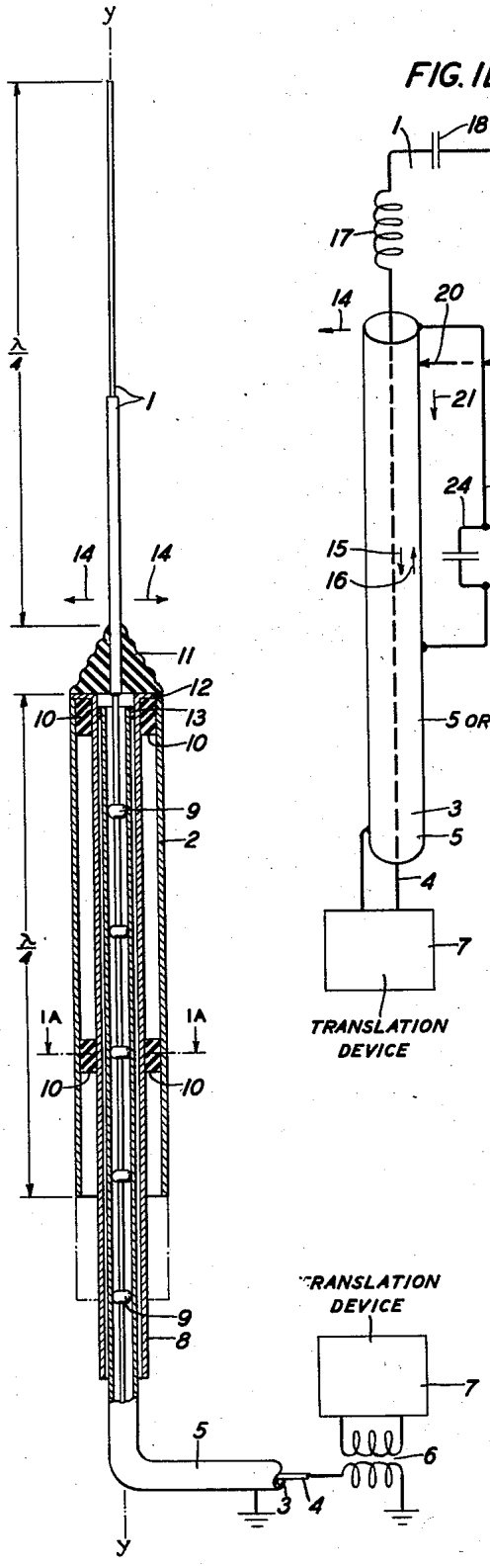
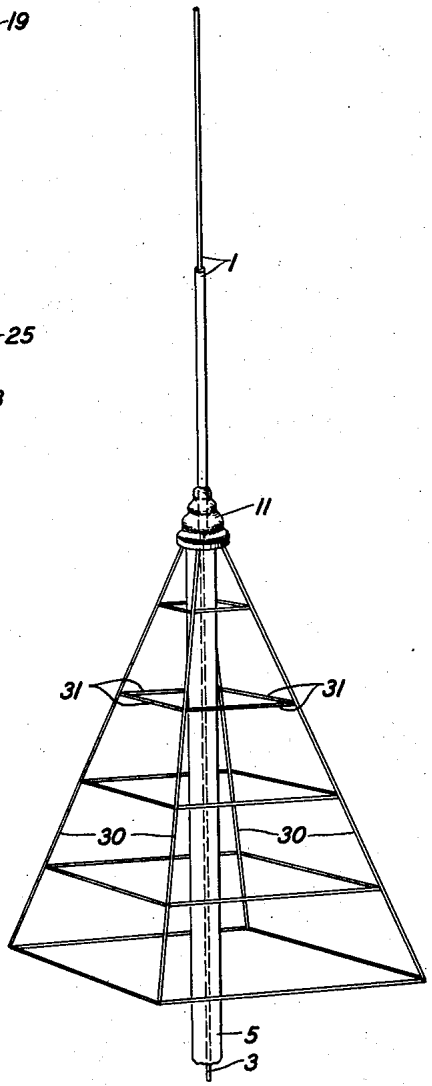


FIG. 1B

FIG. 2



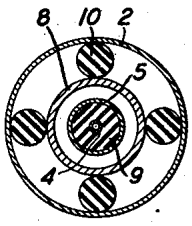


FIG. 1A

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FIG.3

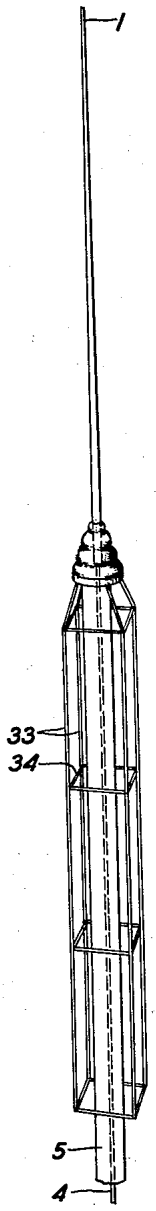


FIG.4

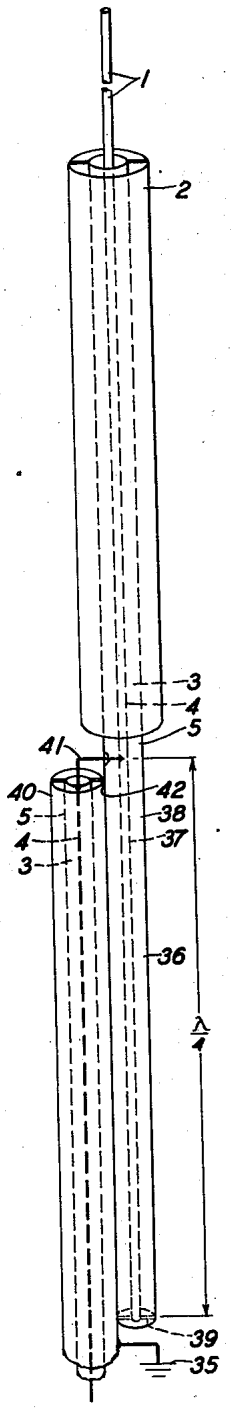


FIG.5

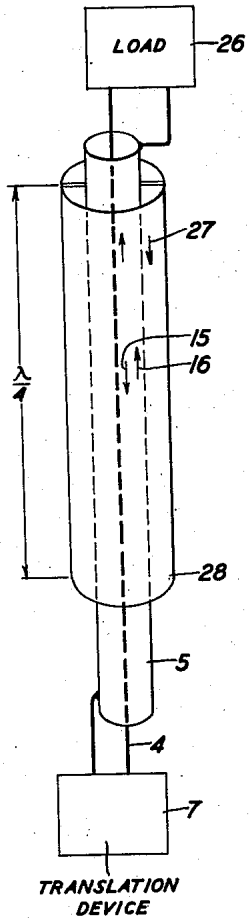
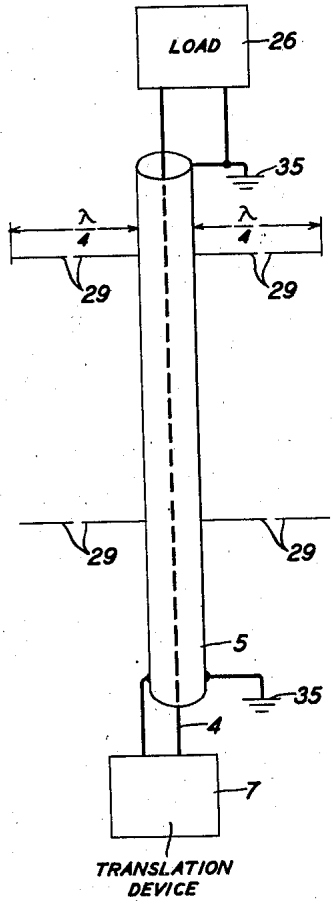


FIG.6



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Patented Dec. 26, 1939

2,184,729

UNITED STATES PATENT OFFICE

2,184,729

ANTENNA SYSTEM

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Application April 15, 1937, Serial No. 137,098

11 Claims. (Cl. 250—33)

This invention relates to radio systems and more particularly to antenna-counterpoise systems and to transmission systems.

In the antenna art it has long been recognized that the radiating function or effect of auxiliary apparatus associated with antenna systems, such as an antenna transmission line, must be minimized or compensated in order to preserve the desired directional or non-directional characteristic of the antenna. For the purpose of preventing the normal transmission line currents and the undesired currents induced in the line, from establishing a field in opposition to that of the antenna field, various expedients have been utilized. Thus, open wire lines having closely positioned conductors and lines, such as coaxial lines, in which the conductors have a common axis, have been used for the purpose of balancing or mutually canceling the radiation produced by the normal currents. Lines enclosed in a single shield and open lines having individually shielded conductors have been proposed for eliminating radiations produced by the undesired line currents. In general, these systems have not proven entirely satisfactory, and it appears desirable to eliminate both types of line radiation, especially in systems in which the line is necessarily associated with the central portion of the antenna-counterpoise structure, in a simpler and more efficient manner than heretofore achieved.

Moreover, in the case of unburied coaxial lines connecting a source and load and having its outer conductor or sheath grounded at points relatively far apart as, for example, a line installed on or near the top of a high building, it has been found that undesired longitudinal currents flow or occur on the outer sheath surface because of reflection by the load or because of the potential differences often existing between certain areas and between certain sheath points and the ground. In accordance with the present invention, means are provided for effectively grounding the entire sheath surface whereby the longitudinal currents are eliminated.

One object of this invention is to produce an undistorted radio field of maximum intensity.

Another object of this invention is to eliminate radiation from a transmission line and other auxiliary apparatus associated with an antenna system.

Still another object of this invention is to secure, in practice, an antenna directive characteristic which is the same as the corresponding theoretical characteristic.

A further object of this invention is to prevent, in a coaxial line system, the establishment of currents on the outer surface of the sheath.

According to one embodiment of the invention, the system comprises a solid rod antenna, a tubular counterpoise, and a coaxial line, all colinearly arranged. The line is connected to the input terminals of the antenna and the counterpoise and the line portion adjacent to the radiating structure is enclosed by the counterpoise. The parallel conducting surfaces comprising the inner surface of the tubular counterpoise and the outer surface of the coaxial outer conductor or sheath constitute a circuit having distributed constants of such value as to prevent the establishment or production of undesired currents on the sheath outer surface, whereby the radiation or directive diagram of the antenna is not distorted by sheath radiation and, in the case of a vertical half wave-length antenna counterpoise system, a strong ground wave is secured. At the same time the desired transfer or flow of energy between the antenna and the transmission device is not impeded. The supporting structure preferably comprises a pipe interposed, concentrically, between the cylindrical counterpoise and the cylindrical line sheath and rigidly attached to the central portion of the antenna-counterpoise system.

The invention will be more fully understood from the following description taken in conjunction with the drawing on which like reference characters designate elements of similar function and on which:

Fig. 1 illustrates an embodiment of the invention in which the counterpoise is cylindrical or tubular;

Fig. 1—A illustrates a cross-sectional view of the tubular counterpoise, and Fig. 1—B is a schematic representation useful in explaining the invention;

Figs. 2 and 3 illustrate systems constructed in accordance with the invention and having, respectively, a pyramidal and a square counterpoise;

Fig. 4 illustrates a system similar to that illustrated by Fig. 1 and associated with lightning protection means; and

Figs. 5 and 6 illustrate systems for eliminating currents produced on the outer surface of a coaxial line sheath.

Referring to Figs. 1 and 1—A, reference numeral 1 designates an antenna comprising sections having different diameters and which may be solid or tubular, and reference numeral 2 designates a tubular counterpoise. The antenna-

counterpoise system is connected by means of a coaxial line 3 comprising inner conductor 4 and outer conductor 5, through transformer 6 to a translation device 7 which may be either a transmitter or a receiver. The structure comprising the antenna 1, the counterpoise 2 and the line 3 is supported by a pipe 8; the antenna, the counterpoise, the line and the pipe having a common vertical axis y—y. Reference numerals 9 designate the transmission line insulators and numeral 10 denotes cylindrical insulators positioned between the counterpoise and the pipe 8. Numeral 11 designates an insulator which is interposed between the antenna 1 and the counterpoise 2 and which contributes to the support of antenna 1. A disc-shaped or cylindrical metallic plate denoted by numeral 12 electrically connects the counterpoise 2 to the pipe 8 and a similarly shaped metallic plate designated by numeral 13 connects the pipe 8 and the extremity of the outer conductor 5. The antenna 1 is conductively joined to the inner conductor 4 which may be solid or tubular. The antenna 1 and the counterpoise 2 are each a quater wave-length long, and they constitute a vertical doublet half-wave system.

Assuming that the system is used for transmission, energy is supplied by translation device 7 through transformer 6 and over line 3 to the vertical antenna-counterpoise system 1, 2. The antenna and counterpoise, considered above, radiate a maximum amount of energy non-directively in a horizontal plane, as illustrated by arrow 14. The oppositely phased currents, represented by arrows 15 and 16 in Fig. 1—B and conveyed by the coaxial line produce radiations which mutually cancel since the conductors constituting the sources of the radiations are, as regards the fields established in space thereby, coincident or superimposed.

Referring to the schematic illustration, Fig. 1—B, the high voltage established or existing during the transmission period between the remote terminals of the antenna, which is represented by the distributed inductance 17, distributed capacity 18 and the resistance 19, and points on the outer sheath surface, as for example, point 20, tends to establish an undesirable longitudinal current 21 on the outer surface of the sheath 5. According to applicant's invention, the tubular counterpoise 2 represented by the line 22 in Fig. 1—B, forms with the pipe 8 (or outer conductor 5 if the pipe be omitted) a high impedance circuit or anti-resonant circuit 23 comprising the capacity 24 and inductance 25. The anti-resonant circuit prevents substantial energization by the radiating system of the outer surface of the sheath whereby current 21 becomes zero or negligible. By minimizing current 21 and the resultant undesired radiation, a directional characteristic is obtained which is similar to the theoretical antenna-counterpoise characteristic. In practice, the length of the quarter wave-length antenna is slightly adjusted for the purpose of matching the antenna-counterpoise impedance to the line impedance and the length of the quarter wave-length counterpoise is varied slightly in order to secure the high impedance mentioned above. In the case of reception, the counterpoise functions to shield the line portion positioned adjacent to the absorption structure and exposed to the incoming field, whereby the unbalanced and undesired current ordinarily induced or set up on the outer surface of the sheath by the incoming wave is eliminated.

While the invention is particularly suitable for use in systems in which the load impedance comprises an antenna system, it may be satisfactorily employed with any load impedance. Referring to Fig. 5, the desired line currents travel, as indicated by arrows 15 and 16, along the outer surface of the solid or tubular inner conductor 4 and along the inner surface of the outer conductor 5 to or from the load 26. Assuming that the load and line impedances are not matched, the reflection produced by the load tends to send energy in the form of a reflected wave 27 back toward the translation device or source 7 along the inner conductor 4 and the outer surface of the sheath 5. Again, assuming that the line is located in a strong radio field, or at a considerable distance from the ground as in the case of a high building, serious longitudinal currents often exist on the outer surface of the sheath, even when the line and load are matched. The diameter and length of the tubular sleeve 28 which corresponds in a sense to the counterpoise 2, are adjusted or chosen so that the sleeve and sheath 3 form a high Q or low loss anti-resonant circuit for the surface current with the result that no appreciable undesired standing wave or longitudinal current exists on the outer sheath surface. The sleeve 28 and the associated surface of the outer conductor 5 constitute a short-circuited quarter-wave transformer.

In place of the tubular sleeve 28, one or more discs or wires 29, each having a radius of a quarter wave-length, may be employed, as illustrated by Fig. 6, for the purpose of eliminating the undesired longitudinal current. The disc or wire functions as a radio frequency ground. Each quarter wave plate or wire system 29 is preferably connected to the coaxial line at a point where the surface current is a minimum.

As shown in Figs. 2 and 3, the counterpoise may have a shape other than cylindrical. In the embodiment of Fig. 2, the counterpoise is a self-supporting pyramidal structure comprising the inclined metallic members 30 and the horizontal metallic members 31. In the arrangement of Fig. 3, the counterpoise has a square cross-section and comprises the vertical metallic members 33 and horizontal metallic members 34. In both embodiments the apex or top of the counterpoise is connected to the extremity of the coaxial line outer conductor 5 by means of straps or connections (not shown) similar to the discs or plates 12 and 13. The cross-sectional and longitudinal dimensions of these counterpoises are chosen so that the counterpoise and adjacent portion of conductor 5 constitute a high impedance circuit which, as in the case of the tubular counterpoise of Fig. 1, prevents undesired energization of the outer surface of sheath 5.

Referring to Fig. 4, the antenna-tubular counterpoise 1, 2 is conductively connected to ground 35 through the line 3 and a coaxial quarter wave-length short-circuited impedance transformer 36 of the type disclosed in Patent 1,963,723, E. J. Sterba, June 19, 1934. The coaxial transformer comprises conductors 37 and 38 which are short-circuited at their remote terminals by a strap or disc 39. Strap 39 and the outer surface of conductor 38 are directly connected to a grounded supporting pipe or metallic flag-pole 40, which encloses a portion of line 3. The inner conductor 37 is directly connected to the portion of the inner conductor 4 enclosed by counterpoise 2 and through conductor 4 to the antenna 1, conductor 37 is also connected to the portion of conductor

4 enclosed by pipe 40 by means of the wire connection 41.

In operation, the radio frequency energy supplied by the translation device (not shown) is impressed at connections or points 41 and 42 on the input terminals of the transformer 36 and on the line conductors 4 and 5 enclosed by the counterpoise 2. No energy of the operating radio frequency flows to ground 35 because of the high impedance offered by the transformer 36 to energy of this frequency. On the other hand, energies of other frequencies, including lightning frequencies, induced in the antenna-counterpoise system find a direct or low impedance path to the ground 35.

Although the invention has been described in connection with certain specific embodiments and apparatus, it should be understood that it is not to be limited to these embodiments inasmuch as other structures may be successfully employed without exceeding the scope of the invention. Thus, the antenna, counterpoise and associated line may be horizontally positioned; and the invention may be successfully used for communication at any radio frequency.

What is claimed is:

1. A radio system comprising a radiator and a transmission line connected thereto, a support for said system, a portion of said line and a portion of said support being enclosed by said radiator.

2. In combination, a radiating or absorbing system comprising a pair of colinear members, one of which is tubular, means comprising a coaxial line connected between said members and a translation device, the portion of said line adjacent said system being enclosed by said tubular member.

3. In a radiation or collection system, an antenna member, a counterpoise member, a pair of members connecting said system to a translation device, all of said members having a common longitudinal axis.

4. In a radiation or collecting system, an antenna member, a counterpoise member, a pair of line members connecting said system to a translation device, a support for said members, said antenna member being a colinear extension of one of said line members and said line and supporting members being positioned within said counterpoise member.

5. In a radio system, an antenna, a tubular counterpoise, a translation device, a coaxial line connected to said device and to the adjacent terminals of said antenna and counterpoise, a tubular supporting means rigidly attached to said adjacent terminal of the counterpoise, said counterpoise, coaxial line and supporting means being concentrically positioned, and said line and said means being enclosed by said counterpoise.

6. In a radio system, a radiating structure comprising an antenna and a counterpoise each approximately a quarter wave-length long, a line conductor connected to said structure, a support for said structure and conductor, a portion of said line conductor and support being enclosed by said counterpoise.

7. In a radio system, a radiating structure comprising an antenna and a counterpoise each approximately a quarter wave-length long, a line conductor connected thereto, a support for said structure and line conductor, said counterpoise being cylindrical and a portion of said line conductor and support being enclosed by said counterpoise.

8. In a radio system, a radiating structure comprising an antenna and a counterpoise each approximately a quarter wave-length long, a line conductor connected thereto, a support for said structure and line conductor, said counterpoise being pyramidal, and a portion of said line conductor and support being enclosed by said counterpoise.

9. In a radio system, a radiating structure comprising an antenna and a counterpoise each approximately a quarter wave-length long, a line conductor connected thereto, a support for said structure and line conductor, said counterpoise being oblong and a portion of said line conductor and support being enclosed by said counterpoise.

10. In a radio system, an antenna, a tubular counterpoise, a coaxial line connected to said antenna and counterpoise and having a portion enclosed by said counterpoise, a quarter wave-length coaxial line having one pair of terminals short-circuited and grounded and its other pair connected to said first-mentioned line at a point outside of said counterpoise and immediately adjacent thereto.

11. In a radio system, an antenna, a tubular counterpoise, a coaxial line connected to said antenna and counterpoise, a quarter wave-length coaxial line having one pair of terminals connected together and to the earth through a path of zero impedance and its other pair of terminals connected to the conductors of the first-mentioned line.

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