

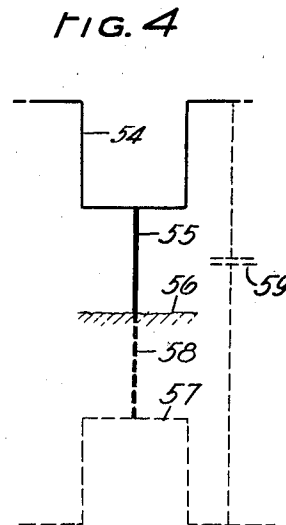
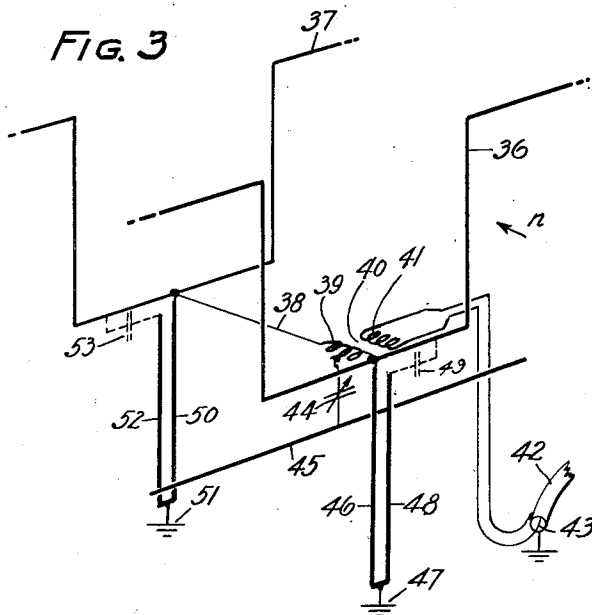
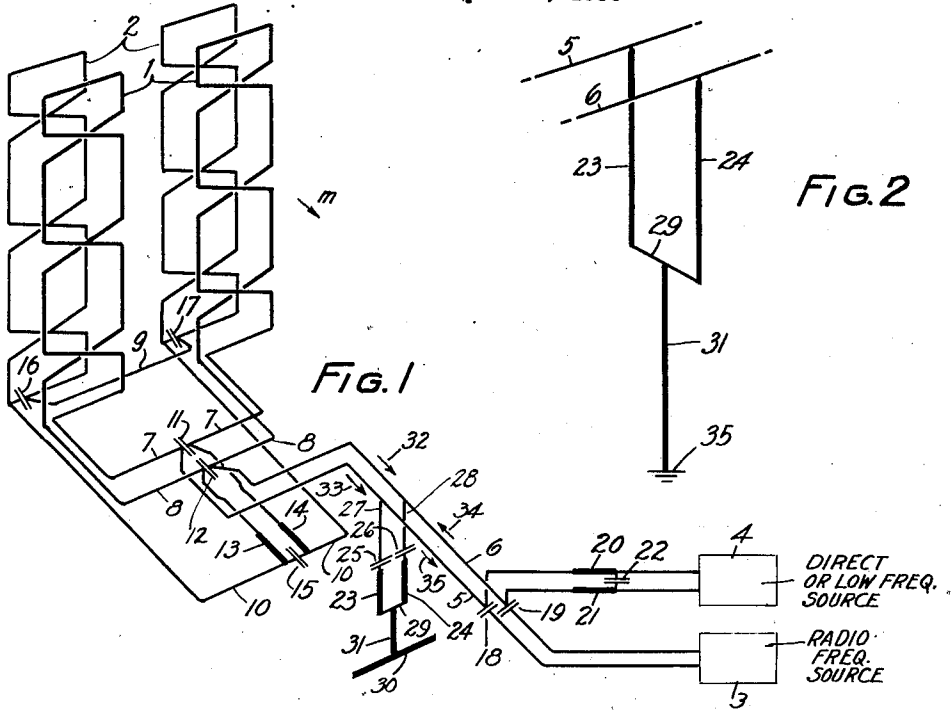
Aug. 29, 1933.

E. B. FERRELL

1,924,115

PROTECTIVE MEANS FOR ELECTRICAL SYSTEMS

Filed April 8, 1930



INVENTOR
E. B. FERRELL
BY *Guy T. Morris*
ATTORNEY

UNITED STATES PATENT OFFICE

1,924,115

PROTECTIVE MEANS FOR ELECTRICAL SYSTEMS

Enoch B. Ferrell, Eaton Town, N. J., assignor
to Bell Telephone Laboratories, Incorporated,
New York, N. Y., a Corporation of New York

Application April 8, 1930. Serial No. 442,483

12 Claims. (Cl. 250—11)

This invention relates to electrical systems and particularly to auxiliary equipment associated therewith for preventing undesired currents from affecting said systems and associated transmitting or receiving apparatus.

It is well known, for example, that it is desirable to ground radio transmitting and receiving aerial systems for lightning and atmospheric voltages induced by external means, since such voltages tend to lower greatly the operating efficiency of the system as a whole and often cause serious damage to the translation apparatus associated with the antenna. In directive systems, the effect of these undesired voltages is even more pronounced, since the directivity is usually materially lessened. Moreover, it is desirable to suppress certain currents originating in the systems themselves such as harmonics of the frequency desired to be radiated or absorbed, since these currents contribute to diminish the operating efficiency.

Practically all of the lightning arresters in use at the present time contain a discharge gap and so possess inherent disadvantages in that an appreciable amount of the high frequency energy desired to be radiated or absorbed leaks to ground through the gap, and the gap itself often becomes permanently short circuited with the result that the aerial is grounded for all currents.

It is an object of this invention to improve the operating efficiency of electrical systems by preventing undesired current from affecting such systems.

It is another object of this invention to remove lightning and other undesired energy from electrical systems.

It is still another object of this invention to prevent lightning and other absorbed voltages from reacting on the translation apparatus of a radio frequency system.

It is a further object of this invention to prevent currents originating in the system itself and having a frequency other than that desired to be radiated or absorbed from affecting the antenna operating characteristic.

One feature of the invention is that the aerial portion of a radio frequency system is connected to ground through a path of infinite impedance for currents of the antenna operating frequency and zero impedance for all other currents, substantially.

Another feature of this invention is the conductive path provided for lightning and undesired currents between the antenna and the ground in shunt to the translation apparatus.

In accordance with this invention, two parallel conductors, each having a length equal to a quarter of the wave length corresponding to the antenna operating frequency, are connected conductively or capacitively between the ground and points of different potential in the aerial system. The points of different potential may be contained in the same or different conductor, as for example, points along an antenna element or corresponding points of a transmission line. The parallel conductors short circuited at one end through the ground form, in effect, an anti-resonant circuit for currents of the antenna frequency similar to the short-circuited impedance transformer described in a copending application of E. J. Sterba, Serial No. 482,210, filed September 16, 1930, and assigned to the applicant's assignee. These conductors form a conductive path to ground for currents of other frequencies.

The parallel conductors may be connected by means of a low radio frequency impedance other than the ground; and a quarter wave length line may be inserted between the ground or the counterpoise and one or both of the parallel conductors, in which case, an effective harmonic suppressor for the even harmonics of the antenna frequency is formed.

Instead of two parallel conductors a single quarter wave length conductor may be employed with satisfactory results, the ground functioning in this case both as a return conductor and a short circuiting means.

The invention will be more fully understood from the following description taken in connection with the drawing in which:

Fig. 1 is a directional transmission system in which one specific embodiment of the invention is utilized for suppressing harmonics and other undesired currents;

Fig. 2 represents an embodiment of the invention adapted to function as a harmonic suppressor and lightning arrester;

Fig. 3 is a directional receiving system in which the invention is employed as a lightning arrester; and

Fig. 4 is a simple embodiment of the invention which may be satisfactorily employed as a lightning arrester.

Referring to Fig. 1, the reference numerals 1 and 2 designate respectively the exciter and reflector of a directional transmitting antenna such as is disclosed in Patent 1,885,151, November 1, 1932, issued to E. J. Sterba. Reference numeral 3 designates a source of high frequency energy desired to be radiated from the antenna system and

numeral 4 represents a source of low frequency energy employed for melting sleet formed on the antenna system. The antenna and energy sources 3 and 4 are connected by means of a transmission system comprising the main conductors 5 and 6 and branch conductors 7, 8, 9 and 10.

Numerals 11 and 12 designate blocking condensers for low frequency current and numerals 13 and 14 represent quarter wave length conductors short-circuited by condenser 15 which possesses a low impedance for radio frequency. The short-circuited quarter wave length conductors 13 and 14 form in effect an impedance transformer such as described in a copending application of E. J. Sterba, Serial No. 482,210, filed September 16, 1930, and assigned to the applicant's assignee. Numerals 16, 17, 18 and 19 designate low frequency blocking condensers. Reference numerals 20 and 21 represent quarter wave length conductors and numeral 22 a short-circuiting condenser, the combination of which is an impedance transformer similar to that just described. Reference numerals 23 and 24 designate quarter wave length conductors arranged in parallel and connected to transmission line conductors 5 and 6, respectively, through low frequency blocking condensers 25 and 26. The connecting conductors 27 and 28 possess negligible length. The remaining terminals of conductors 23 and 24 are short-circuited by low impedance conductor 29. Short-circuited conductors 23 and 24 are connected to a balanced half-wave counterpoise 30, such as disclosed in a copending application of H. T. Friis, Serial No. 420,082, filed January 11, 1930 and assigned to the applicant's assignee, by means of quarter wave length conductor 31.

The operation of the antenna and associated sleet-melting systems are fully described in the above copending applications and will be only briefly outlined here. High frequency energy from source 3 is transmitted over conductors 5 and 6 and through condensers 11 and 12 cophasally to exciter panels 1. Exciter panels 1 and reflector panels 2 cooperate to transmit the energy unidirectionally in the direction indicated by arrow "m". This high frequency energy is prevented from reacting on low frequency source 4 by means of the impedance transformer comprising conductors 20 and 21 and condenser 22. Also, the high frequency energy is prevented from being impressed on the reflector panels 2 by impedance transformer comprising conductors 13 and 14 and condenser 15. Low frequency sleet-melting energy is supplied serially to the right-hand exciter panel shown on the drawing, the reflector panels and to the left-hand exciter panel. Blocking condensers 18 and 19 serve to prevent the low frequency energy from reacting on source 3.

Undesired energy absorbed by the antenna itself is transmitted in phase as shown by arrows 32 and 33 over conductors 5 and 6. Moreover, in-phase currents resulting from an unbalance of the transmitted high frequency energy and having the direction indicated by arrows 32 and 33 are transmitted over the line conductors 5 and 6. The conductors 23 and 24 function as a single conductor in series with conductor 31 for these unbalanced and absorbed currents so that a conductor of low impedance is provided between the counterpoise and transmission line with the result that these undesired currents, hereinafter called "push-push" waves, are prevented

from reacting on high frequency source 3. Preferably conductors 23 and 24 are connected to the line at a point of minimum potential above ground.

The currents desired to be transmitted over conductors 5 and 6 are 180° out of phase as indicated by arrows 34 and 35. The short-circuited transformer comprising conductors 23, 24 and 29 effectively prevent these currents, hereinafter referred to as "push-pull" waves, from flowing to the counterpoise 30. The even harmonics of the fundamental frequency of the above mentioned push-pull waves, however, flow to the counterpoise 30 inasmuch as the transmission path for these harmonics between the line and counterpoise is an even multiple of a quarter wave length. Blocking condensers 25 and 26 serve to prevent the flow of low frequency energy between the line conductors 5 and 6.

In Fig. 2 reference numerals 5 and 6 designate high frequency transmission conductors and numerals 23, 24 and 31 refer to quarter wave length conductors similar to those shown in Fig. 1. Also, as in Fig. 1, numeral 29 designates a conductor of negligible length connecting corresponding terminals of conductors 23 and 24 to each other and to quarter wave length conductor 31. Conductor 31 is grounded as shown at 35.

The system shown in Fig. 2 operates in respect to the push-push and push-pull waves in a manner similar to the system of Fig. 1. In addition, lightning and other atmospheric currents are transmitted from conductors 5 and 6 to ground 35 over the conductive path comprising conductors 23, 24, 29 and 31. The system of Fig. 2 functions therefore to effectively protect the high frequency line from lightning currents and may be substituted for the harmonic suppressor employed in the system of Fig. 1.

In Fig. 3 numerals 36 and 37 designate respectively the exciter and reflector curtains of a directional receiving antenna system connected together by means of quarter wave length conductor 38 in series with primary coil 39 of the transformer 40. A directional receiving system such as shown in this figure is described in Patents 1,813,143, July 7, 1931, and 1,841,085, January 12, 1932, issued to E. Bruce. The antenna is inductively associated with a translation system, not shown on the drawing, by means of secondary transformer coil 41 and concentric line transmission conductors 42 and 43. The primary coil 39 is connected through an impedance varying condenser 44 to a balanced counterpoise 45 similar to that employed in the system of Fig. 1.

Reference numeral 46 designates a quarter wave length conductor conductively connecting the exciter 36 to ground 47 and numeral 48 designates another quarter wave length conductor having one terminal connected to conductor 46 at the ground and its other terminal capacitively associated with exciter 36 through condenser 49. Similarly, quarter wave length conductor 50 connects reflector 37 to ground 51 and quarter wave length conductor 52 is connected at one terminal to ground 51 and at the other terminal to exciter 37 through condenser 53.

As described in the patents of E. Bruce mentioned above, the antenna system of Fig. 3 functions to absorb waves coming from one particular direction as indicated by arrow "n". In other words, this system is unidirectional, the waves having a direction "n" absorbed by exciter 36 and reflector 37 being cumulatively combined in transformer winding 39 and waves having a di-

resection opposite to that indicated by arrow "n" being differentially combined in this transformer winding. The absorbed energy is inductively transferred to secondary winding 41 of transformer 40 and thence conducted over the concentric transmission line comprising conductors 42 and 43 to the translation system. The balanced counterpoise 45 offers minimum impedance to the antenna and reflector currents. The vertical down lead connecting the antenna and counterpoise is comparatively short and therefore absorbs a relatively small amount of energy. Condenser 44 functions to secure the proper phase relation between the antenna and reflector currents.

Lightning and other atmospheric currents having a frequency other than that for which the exciter and reflector are designed, are conductively transmitted over conductors 46 and 50 respectively, to the ground. High frequency currents of the exciter-reflector frequency, however, are impeded from flowing to ground over these paths since conductors 46 and 48 short-circuited by ground 47, and conductors 50 and 52 short-circuited by ground 51, form effectively impedance transformers in the conductive paths, for voltages impressed across the upper terminals of the parallel conductors through condensers 49 and 53, respectively. Moreover, as in the system of Fig. 1, even harmonics of the desired antenna current are removed from the system by conductors 46 and 50 which, for these currents, are an even multiple of a quarter wave length long.

In Fig. 4 reference numeral 54 designates an element of an antenna designed for a particular wave length and numeral 55 designates a conductor an odd multiple of a quarter wave length long connecting the element to ground 56. The "images" of this antenna element and associated conductor are represented by 57 and 58 respectively. Condenser 59 represents the capacitive path between the element 54 and its image 57.

In the system shown in Fig. 4 lightning and currents having a frequency other than that for which the antenna element is designed, flow to the ground over the conductive path 55. Currents of the antenna frequency, however, are prevented from flowing to ground since conductors 55 and 58, which are joined at the surface of the ground 56, form an impedance transformer similar to that already described above. In other words, currents tending to flow, for example, from antenna element 54 through condenser 59, imaginary antenna element 57, imaginary conductor 58, ground 56 and conductor 55 are effectively prevented from flowing by means of the impedance transformer.

Although the invention has been described in connection with certain specific embodiments applied to directional transmitting or receiving systems, it is to be understood that any embodiment of the invention may be applied to both transmitting and receiving systems. Moreover, the invention is equally applicable to long or short wave directional and nondirectional systems.

What is claimed is:

1. In combination with a high frequency system designed for a particular wave length, a straight conductor having uniformly distributed impedance connected between said system and the ground, the length of the entire connection between said system and the ground including said conductor being substantially equal to an odd multiple of one quarter of said wave length.

2. In combination with an antenna designed for a particular wave length, a conductor connecting said antenna to ground at the point of minimum potential difference between said antenna and ground, said conductor having a length equal to an odd multiple of a quarter of said wave length.

3. In combination with a directional receiving antenna system comprising an exciter and a reflector, a conductor connecting said exciter to ground, a second conductor connecting said reflector to ground, said conductors having a length substantially equal to an odd multiple of a quarter of the wave length of the wave desired to be received.

4. In combination with an antenna system designed for a particular wave length, a line comprising a plurality of conductors having a length substantially equal to an odd multiple of a quarter of said wave length, one terminal of one of said conductors being connected to the antenna and the other terminal being connected to another of the said conductors and to the ground.

5. In combination, an antenna receiving system comprising an exciter and a reflector, a plurality of lines each comprising a plurality of conductors having a length substantially equal to an odd multiple of a quarter of the wave length of the wave desired to be received, said lines being short-circuited and grounded at one end, a conductor of negligible length connecting one conductor of one of the said lines to the exciter, and another conductor of negligible length connecting one conductor of another of the said lines to the reflector.

6. In combination, an antenna system comprising an exciter and a reflector, a line comprising a plurality of conductors each having a length substantially equal to an odd multiple of a quarter of the wave length of the wave desired to be received, a terminal of one of the said conductors being connected to the exciter and a terminal of another of the said conductors being connected to the reflector, another conductor an odd multiple of a quarter wave length long, one terminal of which is connected to ground and the other terminal of which is connected to the remaining terminals of the above conductors.

7. In combination with a directional antenna comprising an exciter and a reflector, a translation device inductively associated with said system, means for grounding said exciter and reflector for currents having a wave length other than that for which the antenna is designed comprising a plurality of conductors each having a length substantially equal to an odd multiple of a quarter of the said wave length, one of the said conductors being connected to the said exciter and to the ground, and another of the said conductors being connected to the said reflector and to the ground.

8. In combination, a high frequency transmission line comprising a plurality of conductors, means for grounding said line for waves having a length other than a particular wave length comprising a second line, said second line comprising a plurality of conductors each having a length substantially equal to an odd multiple of a quarter of said particular wave length, one terminal of a conductor of said second line being connected to a conductor of said first line, a terminal of another conductor of said second line being connected to another conductor of said first line, the other terminals of the conductors of the second line being connected together, and a conductor

an odd multiple of a quarter of said wave length long having one terminal connected to ground and the other terminal connected to the remaining terminals of the said conductors of the second line.

9. In combination, a directive antenna designed for a particular wave length, a translation device, a transmission line comprising a plurality of conductors connecting said antenna and said device, an impedance for currents of the antenna wave length comprising a plurality of conductors each being substantially equal in length to an odd multiple of a quarter of said wave length and connected at one terminal thereof to a different transmission line conductor, a conductor having a length substantially equal to an odd multiple of a quarter of said wave length, one terminal of the last mentioned conductor being conductively associated with the remaining terminals of the said impedance conductors and the other terminal being connected to ground.

10. In combination, a directive antenna designed for a particular wave length, a translation device, a transmission line comprising a plurality of conductors connecting said antenna and said device, an impedance for currents of the antenna wave length comprising a plurality of conductors each being substantially equal in length to an odd multiple of a quarter of said wave length and connected at one terminal thereof to a different transmission line conductor, a conductor having a length substantially equal to an odd multiple of a quarter of said wave length, one terminal of the last mentioned conductor being connected with the remaining terminals of the impedance con-

ductors and the other terminal connected to a counterpoise.

11. In combination, a directional transmitting antenna, a source of radio frequency energy, a source of low frequency energy, a transmission line comprising a plurality of conductors connecting said sources to said antenna, impedance means for preventing the even harmonics of the current supplied by said radio frequency source from affecting said antenna and for preventing waves absorbed by said antenna from affecting said sources, said means comprising a plurality of conductors each having a length equal to an odd multiple of a quarter of the wave length of the current supplied by said radio frequency source, one terminal of one of the said impedance conductors being connected to one transmission line conductor and a terminal of another of the said impedance conductors being connected to another of the transmission line conductors, a conductor an odd multiple of a quarter wave length long one terminal of which is connected to the remaining terminals of the said impedance conductors and the other terminal of which is connected to a counterpoise, and a condenser in series with said impedance conductors.

12. In combination with an antenna system designed for a particular wave length, a conductor connected between said system and the ground, the length of the entire connection between said system and the ground including said conductor being substantially equal to an odd multiple of a quarter of said wave length.

ENOCH B. FERRELL.

40	115
45	120
50	125
55	130
60	135
65	140
70	145
75	150