Jan. 18, 1938. F. F. MERRIAM 2,105,925

ANTENNA SYSTEM

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FIG. 1

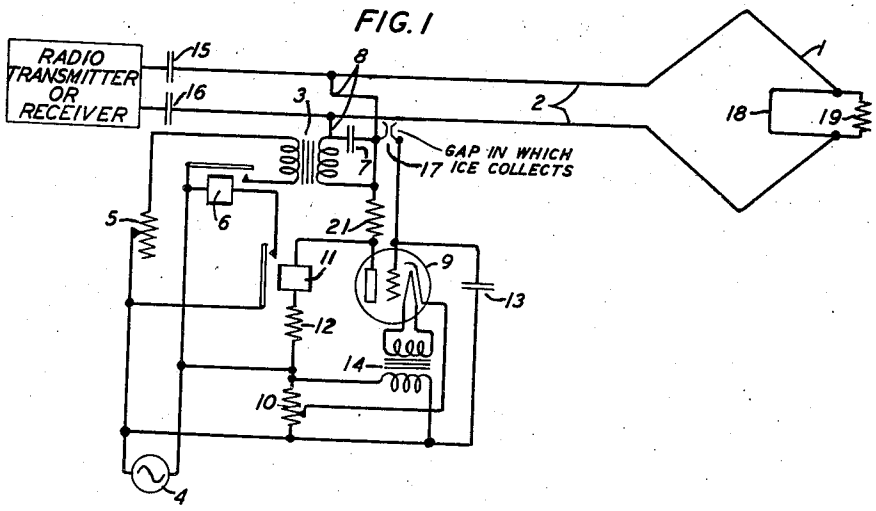
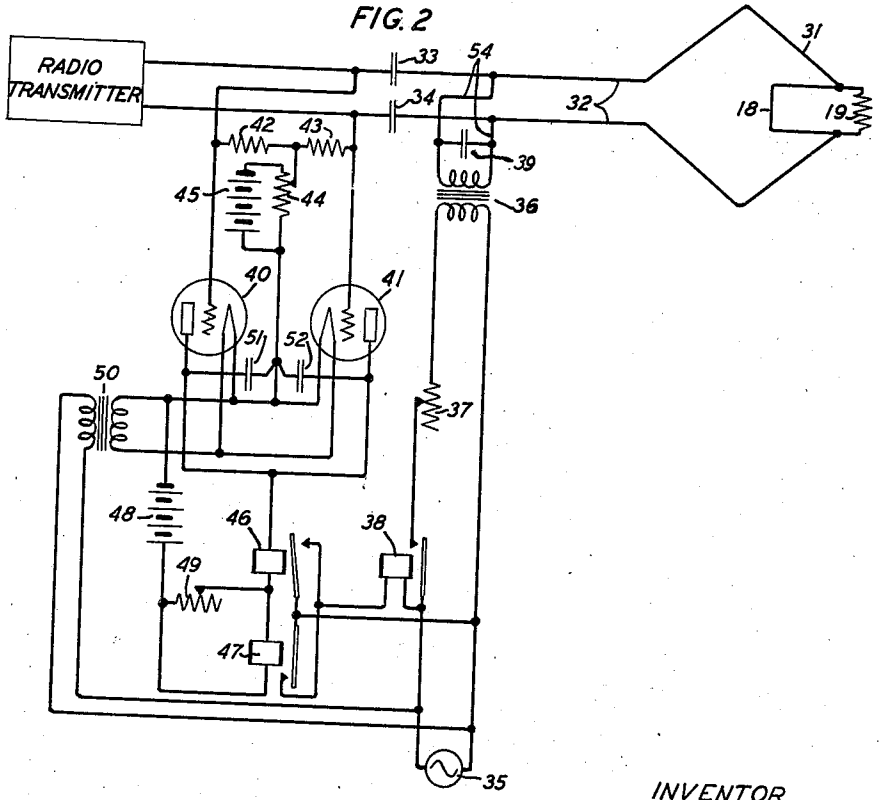


FIG. 2



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FIG. 3

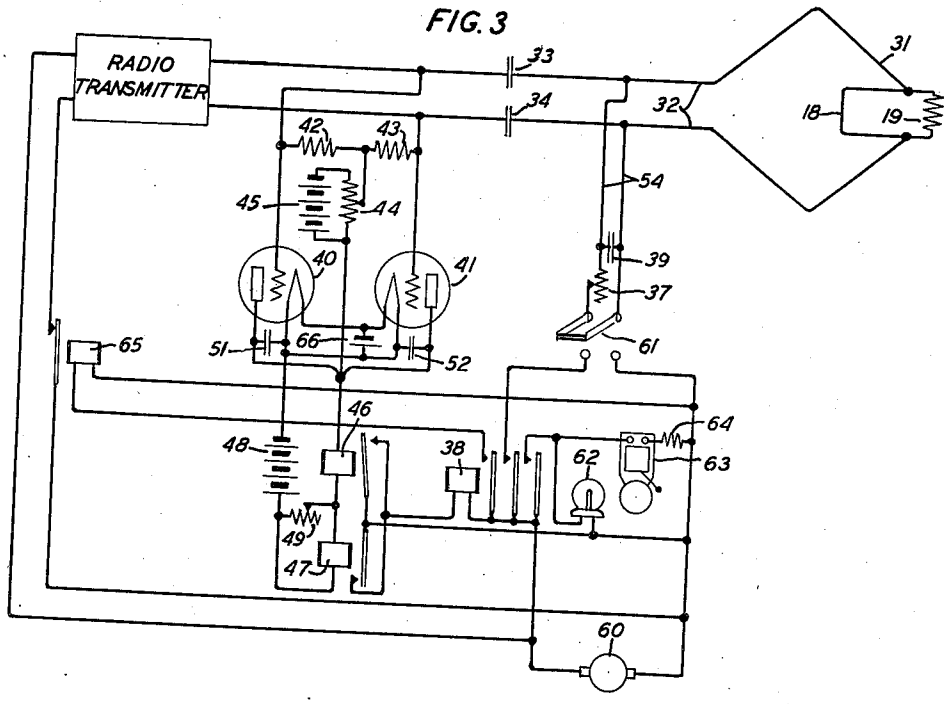


FIG. 4

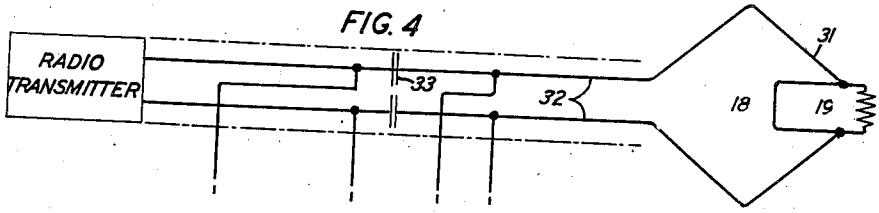
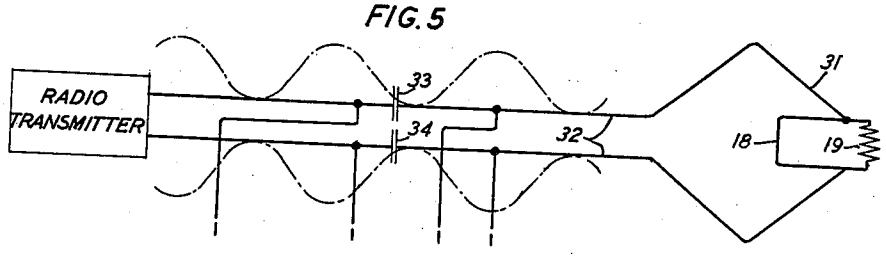


FIG. 5



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Patented Jan. 18, 1938 2,105,925

UNITED STATES PATENT OFFICE

2,105,925

ANTENNA SYSTEM

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Application August 25, 1934, Serial No. 741,356

16 Claims. (Cl. 250—33)

This invention relates to antenna systems and more particularly to a system and method of removing sleet or ice from antennae.

An object of this invention is to prevent the formation of sleet on antennae.

Another object of this invention is to remove sleet on antennae employed in short wave radio systems automatically.

Another object of this invention is to disable a radio system when abnormalities occur which result in the production of standing waves on the line between the transmitter and the antenna of the system.

In certain radio communication systems, especially those employed as an adjunct to land telephone lines, repeaters and other remotely controlled stations are left unattended. During cold weather, the antennae of these stations at times accumulate considerable ice and sleet. The presence of ice and sleet on antennae materially affects the quality of short and ultra-short wave transmission and reception employed on these systems.

In short and ultra-short wave radio systems, highly directive antennae are employed. Ordinarily the impedance of the antennae and of the line connecting the transmitting apparatus to the antennae are balanced. This balancing of impedances at the junction point of the transmitting antenna and the line results in the more efficient transfer of energy to the antenna and in lower line losses. When this matching of impedance is destroyed, standing wave voltages are produced on the line. The presence of sleet on the antenna due to the variation in the capacity of the antennae and other causes changes the impedance relation at the junction point of line and antenna.

In accordance with a feature of this invention, a source of heating energy responsive to the presence of standing waves on the line is applied to the antenna. This heating energy melts the sleet or ice whereby the standing wave voltage is removed from the line and the balanced impedance relation at the junction point of line and antenna is restored. When the standing wave voltage is removed from the line, the antenna is no longer supplied by the heating source.

In one modification, the existence of standing waves on the line between the transmitter and the antenna, due to causes such as the breaking of the line, disables the transmitter.

In accordance with another feature of this invention, sleet or ice is removed from an antenna by automatically supplying heating current through the antenna intermittently as required. Whenever ice is formed on part of the antenna, the power current passes through the antenna and when the ice is melted on that part of the antenna, the power current is removed.

A more comprehensive understanding of this invention may be obtained by reference to the drawings in which:

Fig. 1 is a schematic of a circuit embodying this invention in which heating current is supplied to an antenna intermittently as required when sleet forms on the antenna;

Fig. 2 is a schematic of a circuit embodying this invention in which alternating current is supplied to an antenna when standing waves are produced between the transmitter and antenna of the system;

Fig. 3 is a schematic of a circuit embodying this invention in which heating current from a direct current source is applied to an antenna of a radio system and in which the transmitter of the system is disabled when standing waves occur on the line between the transmitter and antenna of the system;

Fig. 4 is a representation of the voltage along the line leading from a transmitting apparatus to an antenna of the circuit shown in Figs. 2 and 3 when no sleet or ice is formed on the antenna; and

Fig. 5 is a representation of the voltage along the same line as that shown in Figs. 2 and 3 when sleet or ice forms on the antenna.

In Fig. 1, a radio transmitter or receiver, indicated as such in the rectangle, supplies or receives signaling energy to or from a closed circuit antenna 1 of the rhombic type by means of an open wire transmission line 2. A means for supplying heating energy to the antenna comprises an alternating current generator 4. The current passes from the generator through a current regulating rheostat 5, the primary winding of a transformer 3 and the armature and make contact of a relay 6. From the secondary of transformer 3 the current passes to the line 2. A filter comprising a condenser 7 shunted across the secondary of transformer 3 and a quarter wave length line 8 in series with the secondary of transformer 3 is inserted between secondary of the transformer 3 and the line 2. The filter comprising the condenser and quarter wave length line prevents the radio frequency power from the transmitter from entering the circuits of the heating current source. This type of filter is described in a paper entitled "Theoretical and Practical Aspects of Directional Transmitting

Systems" by E. J. Sterba, published in the Proceedings of the Institute of Radio Engineers, July 1931, vol. 19, No. 7, pages 1184 to 1215. Each of the leads of the line 8 is connected at opposite points on the transmission line 2 in order that the electrical symmetry of the line 2 may not be disturbed.

The control electrode of a space discharge device 9 of the equipotential cathode type is connected to one side of the line 8 through a gap 17. The gap 17 is located in the system so that when atmospheric conditions are such that ice forms on the antenna, ice also collects in the gap 17. It is preferable to locate the gap at a point which is at low radio frequency potential. The cathode of device 9 is connected through a potentiometer 10 to one terminal of the generator 4. Connected across the output of the device 9 is a relay 11 in series with a resistance 12. The engagement of the armature of relay 11 and its make contact results in the energization of the alternating current relay 6 from current supplied by the source 4. A condenser 13 connected in series with the potentiometer 10 is shunted across the input circuit of device 9. Heating current is supplied to the filament of device 9 by the generator 4 through a transformer 14. The current for the anode of device 9 is supplied from the generator 4 through a resistance 12 and winding of relay 11. Two condensers 15 and 16 are respectively inserted in series with each side of the line 2 to prevent the alternating current from the heating source, which is of course of much lower frequency than the radio frequency signaling currents, from damaging the radio apparatus. A current limiting resistance 21 is connected between the secondary of transformer 3 and the anode of device 9.

A half wave length loop 18 is connected in series with the antenna 1 and in parallel with a terminating resistance 19. This half wave length loop provides a low resistance path for the lower frequency alternating current employed for heating the antenna wire around the terminating resistance without interfering with the function of the terminating resistance.

The operation of the circuit is as follows: Normally no appreciable current passes in the output of device 9 due to the negative bias on the control electrode. This negative bias is produced by the imposition of part of the alternating electromotive force generated by the source 4 upon the rectifying circuit consisting of condenser 13 and the control electrode and cathode of device 9. When ice or sleet forms on the wires of the transmitting line 2, the ice gap 17 is closed and its resistance is lowered to a value which permits the negative charge to leak off the control electrode, or in other words substantially lowers the negative bias of the control electrode of device 9. The width of the gap 17 is so proportioned that it is not closed by water during a rain storm. The gap is preferably of the horn type as shown in the drawings. The current in the output circuit of device 9 increases sufficiently to energize relay 11. The engagement of the armature and contact of relay 11 due to this energization results in the actuation of relay 6 with the resulting engagement of the contact and armature of relay 6. The actuation of relay 6 results in application of current from the generator 4 through the transformer 3 and the lines 8 and 2 to the antenna 1. This low frequency current melts the ice or sleet on the antenna wires. When the temperature of the antenna and line wires has increased sufficiently to cause the sleet or ice to melt, the ice in the gap is also melted by the heat conducted from the transmission line wires to the gap and the gap opens. The opening of the gap results in the normal negative bias being again impressed on the control electrode of device 9. As a consequence, no appreciable current passes in the output of device 9. Relay 11 is deenergized and the source of heating current from source 4 is removed from the line by the disengagement of the make contact and armature of relay 6. The heating circuit is accordingly restored to its normally inoperative condition.

The system shown schematically in Fig. 2 depends upon the existence or non-existence of standing waves on the line leading from a radio transmitter to an antenna. The system shown in this figure differs from the system shown in Fig. 1 mainly in respect to the principle employed for turning the power on or off.

In Fig. 2 a radio transmitter indicated as such in the rectangle is connected to an antenna 31 by means of a line 32. Two blocking condensers 33 and 34 are inserted respectively in series with each side of the line 32. The heating current for melting the sleet or ice on the antenna 31 is supplied by an alternating current generator 35 through the primary winding of a transformer 36, the current regulating resistance 37 and the contact and armature of an alternating current relay 38. The secondary winding of the transformer 36 is connected to the line 32 by means of a quarter wave length line 54. A condenser 39 is bridged across the line 54. The condenser 39 and the quarter wave length line serve as a filter for preventing the radio frequency power from entering the heating system.

Between the blocking condensers 33 and 34 and the radio transmitter, the control electrodes of two space discharge devices 40 and 41 are connected in push-pull relation. Two resistances 42 and 43 are connected in series and shunted across the control electrode of devices 40 and 41. The resistances 42 and 43 are connected directly across the line 32. A potentiometer 44 connected to a unidirectional current source 45 is connected between the common point of resistances 42 and 43 and the cathodes of devices 40 and 41. The potentiometer 44 impresses a sufficient negative bias potential on the grids of devices 40 and 41 to normally prevent their operation. Two relays 46 and 47 in series are connected in the output circuit of devices 40 and 41. A unidirectional current source 48 supplies the devices 40 and 41 with anode current through relays 47 and 46 or through biasing resistance 49 and relay 46. The sensitivity of relay 47 is changed by varying the biasing resistance 49. The cathodes of devices 40 and 41 are heated by current supplied from the source 35 through a transformer 50. Two condensers 51 and 52 are shunted across the cathode and anode of devices 40 and 41, respectively.

A terminating resistance 19 is connected in series with the antenna 31. When this terminating resistance is connected in series with the antenna, the formation of sleet or ice on the antenna results in a mismatch of impedances at the point of connection between antenna and line. This mismatch of impedances causes the production of standing waves on the line, their amplitude depending upon the degree of mismatch. A half wave length loop 18 in parallel with the resistance 19 provides a low resistance path for the alternating current employed for heating the antenna wire around the terminating resistance 19. Each

of the leads connecting the control electrodes of devices 40 and 41 to the transmission line 32 and each of the leads of the half wave length loop 18 are connected respectively at electrically opposite points on the transmission line 32 in order that the electrical symmetry of the line 32 may not be disturbed.

The operation of the system shown in Fig. 2 may be more clearly understood by reference to Figs. 4 and 5. The numeral designations shown in Figs. 4 and 5 are the same as those in Fig. 2. The dotted line parallel to the line 32 of Fig. 4 represents the normal voltage existing along the line 32 when the system is functioning properly. The dotted lines of Fig. 5 represent the existence of standing wave voltages along the line 32 when sleet forms on the antenna 31.

In Fig. 2 normally just sufficient current passes in the output circuit of devices 40 and 41 so that the relay 46 is energized to prevent the engagement of its break contact with its armature. Relay 47, on the other hand, is deenergized when the radio frequency voltage on the transmission line 32 is normal (i. e. that represented by the dotted line in Fig. 4). The engagement of contact and armature of relay 47 or the contact and armature of relay 46 results in the energization of relay 38. The energization of relay 38 results in the engagement of its contact and armature. This action causes heating current from the generator 35 to be supplied to the antenna 31 through the transformer 36, line 54 and line 32. When standing wave voltages such as those illustrated in Fig. 5 are produced on the line 32, either the nodes deenergize relay 46, or the antinodes energize relay 47. Either the deenergization of relay 46 or the energization of relay 47 results in the actuation of relay 38 with the consequential supply of heating current to the antenna.

When sleet or ice forms on the antenna, standing wave voltages, such as those illustrated in Fig. 5, are produced on the line 32. The existence of nodes or antinodes of these standing wave voltages results in a change in the electromotive force impressed on the control electrodes of devices 40 and 41. If the nodes are at or near the point of the line 32 at which devices 40 and 41 are connected, a decrease in current of the anode circuit which deenergizes relay 46 results, while when the antinodes are at or near the point, an increase in current in the anode circuit which energizes relay 47 is produced. Relay 38 is actuated and heating current passes from the source 35 through the transformer 36, line 54, line 32 to the antenna 31. When the sleet has melted off the wires of the antenna 31, the line voltage returns to normal or that represented by the dotted line in Fig. 4. The voltage impressed upon the control electrode of devices 41 and 40 is then such that relay 46 is energized and relay 47 is deenergized. The armature of relay 38 disengages from its contact and the source of heating current is disconnected from the line 32.

Fig. 3 shows a system for supplying a heating current from a direct current source to an antenna and for disabling the radio transmitter of the system when standing waves are produced on the line between the radio transmitter and the antenna. The manner of supplying the heating current and the apparatus employed for this purpose are similar to the system shown in Fig. 2. In addition to supplying the antenna with heating current when standing waves are produced on the line between the radio transmitter and antenna, electromagnetic means are actuated to disable the radio transmitter. An indicator, visual or acoustical, or both, is also actuated to apprise the operator at the transmitting station of the production of standing waves on the line. The disability of the radio transmitter and the indication of the production of standing waves on the line are especially advantageous in that abnormalities other than the formation of sleet on the antenna, such as the breaking of the line, which produce standing waves are quickly detected.

The parts of the system, the operation and functions of which are the same as those shown in Fig. 2 have the same numerals in Fig. 3. The description of these parts together with their function in the system is not repeated at this point. Instead of the cathode current supply shown in Fig. 2, a unidirectional current source 66 supplies heating current to the cathodes of devices 40 and 41.

If standing waves are produced on the line 32 the change of electromotive force resulting from the standing waves impressed on the control electrodes of devices 40 and 41 causes the deenergization of relay 46 or the energization of relay 47 in a manner similar to that for the system shown in Fig. 2. If the point of connection of the devices 40 and 41 to the line 32 is at or near a node of the standing waves, a decrease in current in the anode circuit results which deenergizes relay 46, while if the point of connection is at or near an antinode of the standing wave, an increase in anode current is produced which energizes relay 47. Deenergization of relay 46 or the energization of relay 47 results in the energization of relay 38.

One of the armatures of relay 38 with its associated make contact completes a circuit for supplying direct current from a direct current source 60 to the antenna 31. The circuit for supplying heating current to the antenna from the direct current source includes the direct current source 60, one arm of a double throw switch 61, one side of line 54, one side of line 32, antenna 31, half wave length loop 18, antenna 31, the other side of line 32, the other side of line 54, current regulating resistance 37, the other arm of the double throw switch 61, contact and armature of relay 38 to the direct current source 60.

Another armature of the relay 38 with its associated contact completes a circuit for operating a visual or acoustical indicator. The indicator may be an electric lamp 62 or a bell 63. Both the lamp 62 and the bell 63 are supplied with current from the direct current source 60, the bell through a current limiting resistance 64. When the relay 38 is energized the engagement of one of the armatures with its associated contact completes a circuit for the illumination of the lamp 62 and the actuation of the bell 63.

Another armature of the relay 38 with its associated contact completes a circuit for the energization of a relay 65 from direct current source 60. The power for the radio transmitter is supplied from the source 60 through the armature and contact of the relay 65. When the relay 38 is energized the engagement of one of the armatures with its associated make contact results in the actuation of relay 65, whereby the direct current source 60 is disconnected from the radio transmitter to disable the transmitter.

When standing waves are produced on the line 32 relay 46 is deenergized, or relay 47 is energized. Relay 38 is actuated, resulting in the engagement of its three armatures with their con-

tacts. Heating current passes from the direct current source 60 to the antenna 31. The lamp 62 is illuminated and the bell 63 rings. Relay 65 is energized to remove the direct current source supplying the radio transmitter. The removal of the direct current source 60 disables the transmitter. If for any reason, the supply of heating current to the antenna is not desired the circuit from the direct current source 60 to the antenna 31 may be opened by means of the double throw manually operated switch 61. If, for example, the sleet melting system is not required and it is desired to detect any abnormality which produces standing waves on the line or to disable the radio transmitter when these abnormalities occur, the sleet melting system may be removed by the switch 61.

While preferred embodiments of this invention have been illustrated and described, various modifications therein may be made without departing from the scope of the appended claims.

What is claimed is:

1. An electrical system comprising an antenna, a source of heating energy, and means actuated by the formation of a frozen deposit on said system for connecting said source of energy to said antenna and for discontinuing the supply of energy only after said deposit has melted.

2. In a radio system, an antenna, a source of high frequency energy, a line connected between said high frequency source and said antenna, a source of heating energy and means responsive to the existence of standing waves on said line for supplying said antenna with heating energy from said source of heating energy.

3. In combination, an antenna, a source of high frequency energy therefor, a line connecting said high frequency energy source with said antenna, a source of heating energy associated with said antenna and means responsive to changes in the impedance relationship between said line and said antenna for supplying energy from said source of heating energy to said antenna.

4. In a radio system, an antenna, a source of heating energy, a gap in cooperative relation with said antenna whereby a frozen deposit is formed in said gap when sleet is present on said antenna and means responsive to the presence of a frozen deposit in said gap for supplying energy from said source to said antenna.

5. An electrical system, a load, a source of current, a line connecting said source to said load, and means responsive to standing waves on said line to disable said source.

6. In a radio system, an antenna, a source of high frequency current, a line connecting said source to said antenna, means to indicate acoustically the existence of standing waves on said line, and means responsive to standing waves on said line to disable said source.

7. In a radio system, an antenna, a source of high frequency current, a line connecting said source to said antenna, means to indicate the existence of standing waves on said line, means responsive to standing waves on said line to disable said source, and means responsive to standing waves on said line to supply heating current to said antenna.

8. In a radio system, an antenna, a radio transmitter, a source of current for said transmitter, a line connecting said transmitter to said antenna, means to indicate acoustically the existence of standing waves on said line, means responsive to standing waves on said line to remove said source from said transmitter whereby said transmitter is disabled, and means responsive to standing waves on said line to supply heating current to said antenna.

9. In a radio system, an antenna, a source of high frequency current, a line connecting said source to said antenna, a source of heating energy, and means responsive to the existence of standing waves on said line for supplying energy from said heating source to said antenna.

10. In a radio system, an antenna, a source of high frequency current, a line connecting said source to said antenna, a source of heating current, and means responsive to the existence of standing waves on said line for passing a current from said source of heating current through said antenna.

11. A method of melting sleet on a radio antenna comprising supplying heating energy to an antenna in response to the existence of standing waves on the line connecting the transmitter and antenna of the system.

12. A method of removing a frozen deposit from an antenna of a radio system comprising supplying heating energy to the antenna in response to the existence of standing waves on the line connecting the transmitter and antenna of the system and discontinuing the supply of said energy in response to the non-existence of standing waves on said line.

13. In a radio system, an antenna, a source of high frequency current, a line connecting said source to said antenna, space discharge devices connected to said line and responsive to the existence of standing waves on said line, an output circuit connected to said devices, and means controlled by the current in said output circuit of said space discharge devices for indicating the existence of standing waves on said line.

14. A radio system comprising an antenna, a source of heating energy, and means responsive to the formation of a frozen deposit in a part of said system for connecting said source to said antenna and for maintaining the connection during the existence of said deposit.

15. An electrical system, a source of heating energy, and control means directly actuated by every change in the impedance of a part of said system for connecting said source to said system.

16. An electrical system comprising a plurality of exposed conductors, a source of heating energy, means directly responsive, irrespective of the temperature of said conductors, to the presence of a frozen deposit on one of said conductors for supplying energy from said source to at least one of said conductors during the entire period said deposit exists and immediately discontinuing the supply upon removal of said deposit.

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