May 26, 1936. N. E. LINDENBLAD 2,042,319

ANTENNA

Filed June 23, 1930 3 Sheets-Sheet 1

Fig. 1

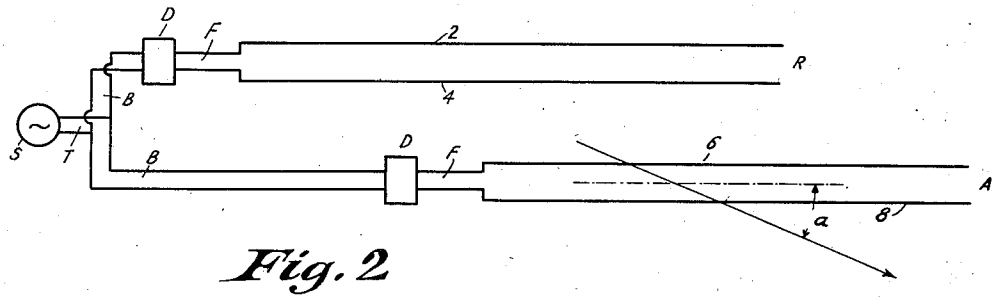


Fig. 2

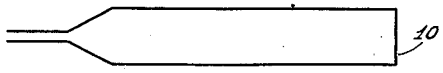


Fig. 3

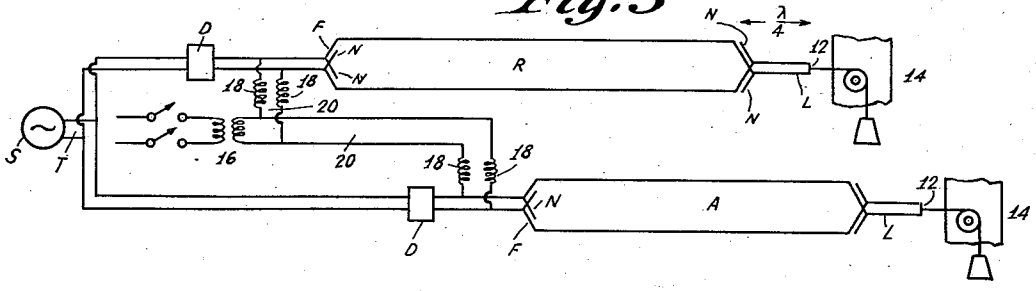
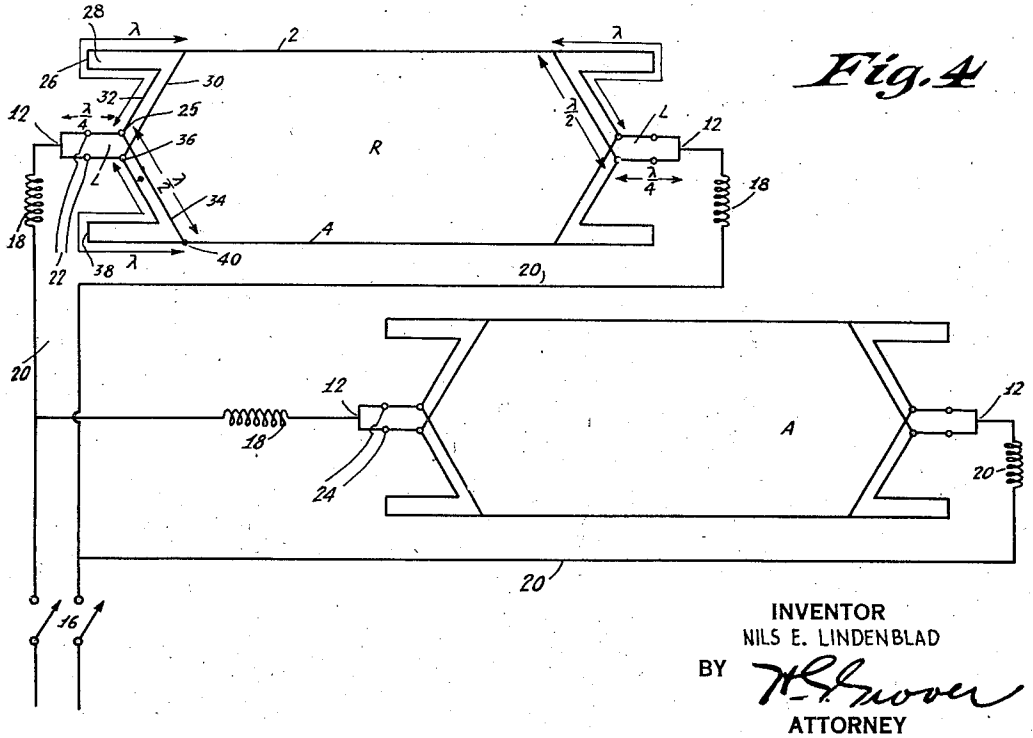


Fig. 4

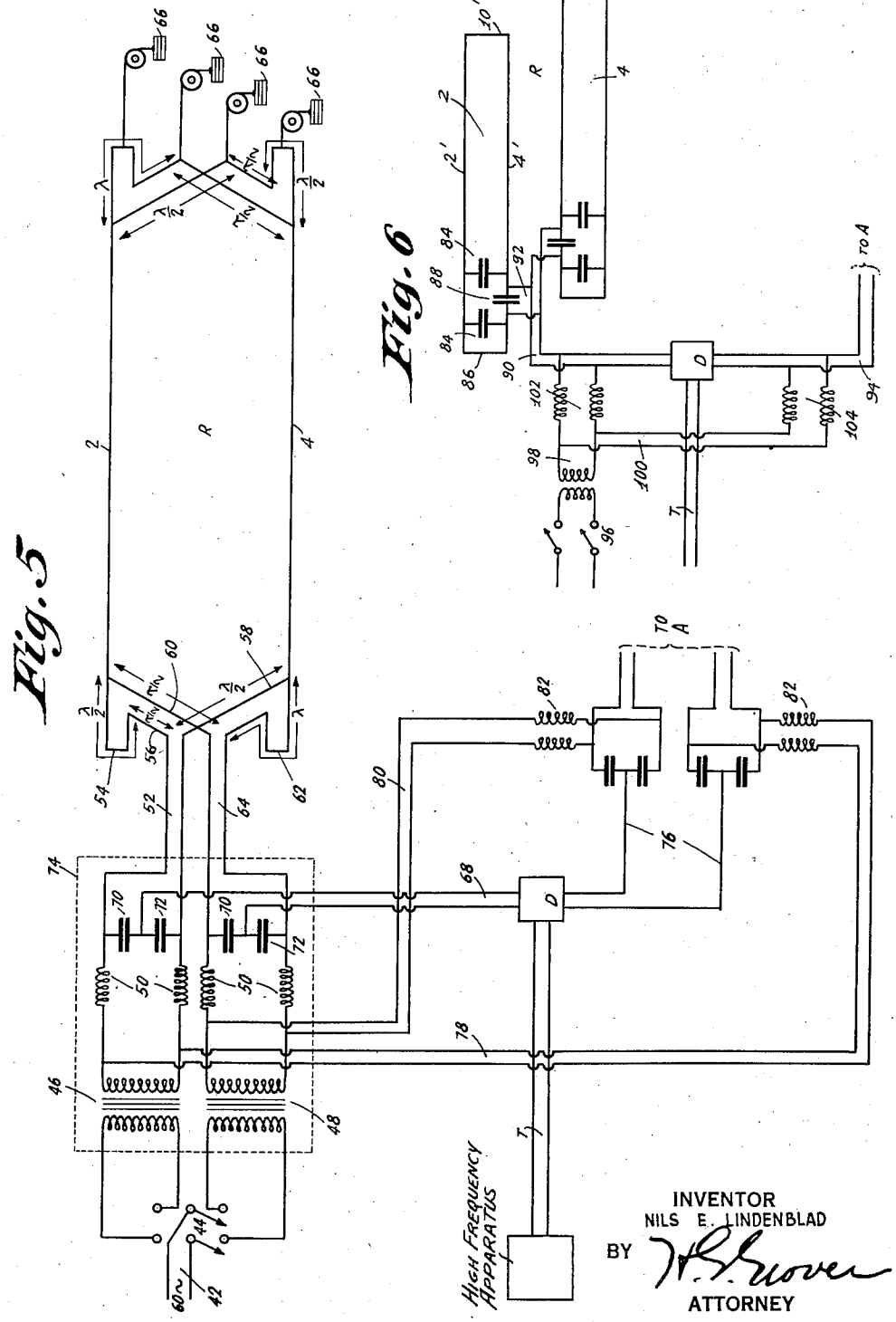


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Fig. 7

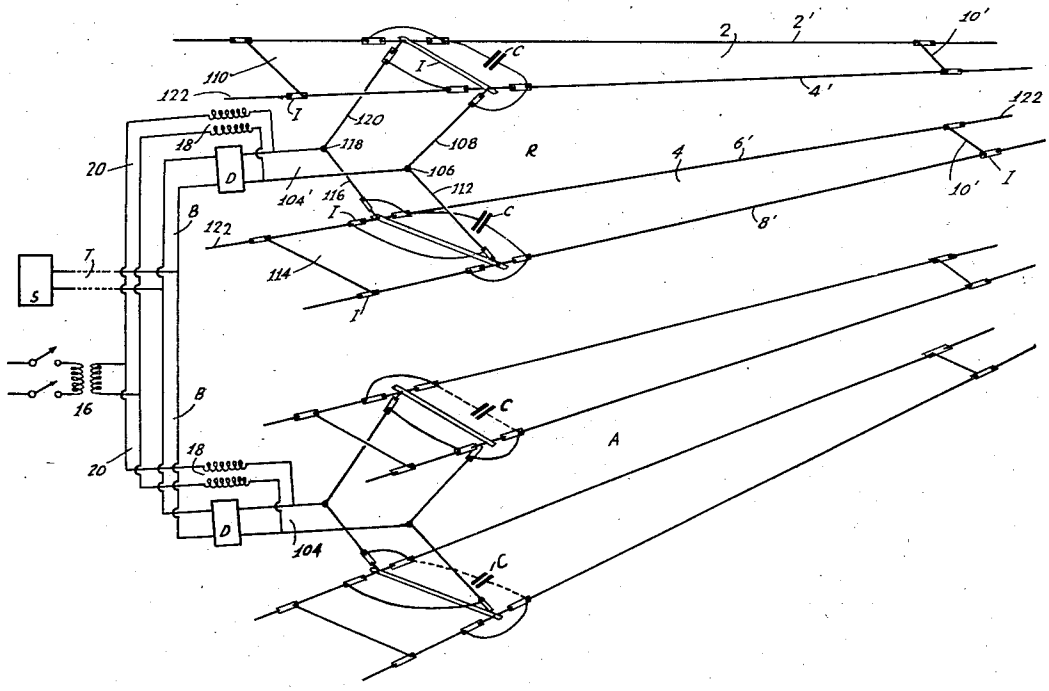


Fig. 9

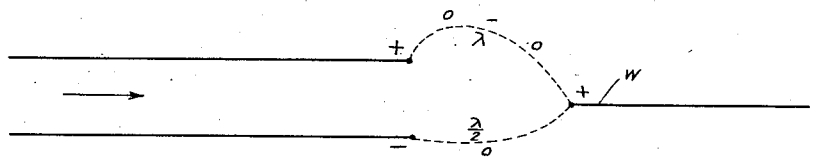
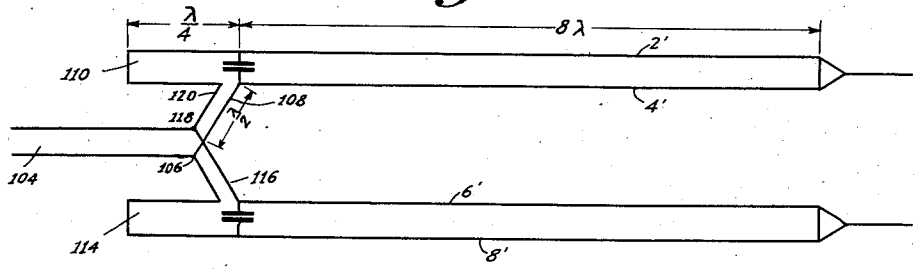


Fig. 8



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Patented May 26, 1936

2,042,319

UNITED STATES PATENT OFFICE

2,042,319

ANTENNA

Nils E. Lindenblad, Port Jefferson, N. Y., assignor to Radio Corporation of America, a corporation of Delaware

Application June 23, 1930, Serial No. 463,024

4 Claims. (Cl. 250—33)

This invention relates to antennae and has for one of its objects the provision of an antenna system adapted to have heating energy supplied to the radiators thereof in a fashion such that the directivity pattern of the antenna is not impaired.

The removal of frozen deposits from antennae is desirable for several reasons. The conductors, forming the antennae, and, the supports therefor need not be designed to support sleet and ice loads and may be made materially lighter. Consequently, with sleet melting apparatus, the antenna presents a saving in initial cost. Moreover, with sleet removed from the wires of the antenna, shaking thereof in the wind is decreased resulting in lessened variations in tuning; and furthermore, for this reason, does not require such strong conductors as would otherwise be the case. In addition, ice load on the conductor changes the electrical properties thereof, sets up reflection points and in general tends to spoil the radiation characteristics of a directive antenna towards which this invention is especially directed.

The problem of heating the various elements of an antenna system may involve radical changes in antenna construction due to the fact that desired radiational characteristics of the antenna may depend upon certain electrical properties of the antenna which must not be altered; for example, it may be required of the antenna that several of the conductors constituting it must be effectively open ended. Accordingly, a further object of my invention is to provide antennae adapted to have heating energy supplied thereto and which may be used with equal efficiency as compared with an antenna for which heating has not been provided so that the same standard type of antennae may be used in any part of the world. That is to say, it is a purpose of this invention to provide antennae adapted for heating which have similar characteristics to those antennae similar in operation but not having heating circuits.

In order to prevent extraneous radiations from feeder members supplying directional antennae with energy to be radiated, it is desirable to neutralize, by means of neutralizing elements, radiation from the feeders. As neutralization requires predetermined phase relationship of the waves on the feeders and on the neutralizing elements which may be upset by sleet deposits thereon, it is a further object of this invention to provide for, in addition to sleet melting for the radiators, sleet melting for the feeder members and neutralizing elements.

The present invention will be further described hereinafter in connection with antennae of the type described in my United States Patent No. 1,884,006, granted October 25, 1932, and neutralizing means of the general type described in my United States Patent No. 1,902,086, granted March 21, 1933. However, it is to be clearly understood that the principles and features of the present invention as defined with particularity in the appended claims are not to be limited to the type of antennae and neutralizers referred to, but are applicable in general, to any radiating system.

In the accompanying drawings, Figure 1 indicates a type of antenna described and claimed in my Patent No. 1,884,006 referred to, to which the present invention is especially applicable,

Figure 2 illustrates a simple type of heating circuit therefor which, however, I consider inoperative for the reason that it ruins the desired radiation characteristic of the antenna,

Figure 3 indicates a preferred form of the invention which, however, does not allow of heating of neutralizing elements for certain portions of the feeders,

Figure 4 is another preferred form of my invention wherein heating is provided for all of the elements involved,

Figure 5 discloses another arrangement wherein sleet melting is provided for feeders, neutralizers and radiators,

Figures 6 and 7 indicate a new type of antenna wherein a plurality of wires are substituted for each of the radiators of the antenna of Figure 1 which wires are effectively in parallel for radio frequency energy but in series for heating energy, and

Figures 8 and 9 are given by way of explanation of certain of the radiating systems.

In Figure 1, which diagrammatically represents my invention claimed and described in my Patent No. 1,884,006 and towards which the present invention is especially directed, a source S of modulated radio frequency energy supplies with energy, through transmission line T, branch lines B and impedance matching devices D and feeders F, radiating elements A and R which may be considered respectively an energized antenna and an energized reflector. Radiating element or reflector R comprises two wires **2**, **4**, upon which are produced standing waves opposed in phase. Similarly, upon the radiating wires **6**, **8** of radiating element or antenna A, are produced stand-

ing waves of opposite phase. Depending upon the dimensions of the antenna system comprising the reflector and antenna and the frequency of the energy supplied to the system, there will be sharp radiation in the direction of the arrow making the angle α with the longitudinal axis of the system.

To supply heating energy to the radiating elements, it may be thought advisable to connect a jumper wire **10** as shown in Figure 2 across the free ends of the elements and to supply through suitable choking devices heating energy to the wires of the radiating elements in series. However, such a procedure will involve radiation from jumper **10** at least equal in value to that from the other wires of the element spoiling the radiation pattern of the system, and, for the purposes of long distance transmission will make the system practically unfeasible.

The arrangements next to be described, namely, the systems in the remaining figure in the drawings, do not present the objection of Figure 2 and are, therefore, preferred thereover.

In Figure 3 energization of the radiating elements R, A is similar to that disclosed in connection with Figure 1. The feeders F in this case are, however, Y-shaped and neutralizers N consisting of open ended wires having standing waves thereon of opposite polarity to the waves on feeder members F cancel radiation from the feeder members. The radiating elements are terminated at their far ends by U-shaped loops L as shown substantially one-quarter wave length long. Because of their close proximity, the legs of the U-shaped loop do not radiate energy; for, the currents carried thereby are 180 degrees out of phase and produce in space substantially concentric opposed fields. As the loop is substantially one-quarter wave length long; or in other words, one half wave from end to end, it acts as a tuned circuit and presents substantially infinite impedance or, in other words, is substantially an open circuit for the wires forming each radiating element. As the point **12** of the loop is a voltage nodal point, it may be safely grounded without the interposition of insulators. This feature of the loop, its characteristics and its use are more fully described and claimed in my United States Patent No. 2,000,032, granted May 7, 1935. The ends of the elements may, of course, be suitably fastened or counter-weighted to supports as at point **14**.

The arrangement of Figure 3 allows of successful sleet melting on the feeders and radiators of the system. Thus, heating energy from a source **16** may be applied through radio frequency chokes **18** across the feeders as shown. In this manner, heating energy passes from source **16** over heating lines **20** and over the wires forming the radiating elements and through the loops L. Even though heating energy is not applied to the neutralizers of this figure, a substantial amount of the system is supplied with sleet melting current and consequently, the simplicity of the arrangement, readily apparent, offers many advantages despite the fact that there may be some accumulation of frozen deposits upon the short open ended neutralizing wires N. While the source of heating energy as shown in connection with Figure 3 and several other figures of the drawings has been indicated to be a low frequency alternating current, it is to be understood that if desired unidirectional energy may be employed if found expedient.

The form of my invention which I most prefer is disclosed in Figure 4 wherein sleet melting current is provided for the radiators, feeders and neutralizing means. Radio frequency energy is supplied to each element through closely parallel leads **22**, **24**, which, because of this fact, do not radiate an appreciable amount of energy. Heating energy is supplied from a source **16** across the voltage nodal points **12** of the radiating elements through lines **20** as shown. As an added precaution, chokes **18** may be inserted in lines **20** but, it is to be clearly understood that as points **12** are nodal points, chokes **18** may be entirely dispensed with. The radiating elements act as parallel loads across the heating source. One terminal **25** of the loop L of radiating element R of Figure 4, is connected to radiator **2** through a path or conductor **26** doubled or looped upon itself at **28** so as to preclude radiation from that portion thereof and paralleling wire **30** at its portion **32**. The terminal **25** is connected to the radiating wire **4** through a wire **34** one-half wave length long. Terminal **36** is similarly connected by means of a wire **38** one wave length long to wire **4** and to wire **2** by means of wire **30** one-half wave length long. Because they are parallel and closely adjacent the wires of loop **28** and the corresponding portion of wire **38** will not radiate energy. Similarly, wires **32** and **30** and the adjacent portions of wire **34** and wire **38** will not radiate energy.

Because of the difference in length of the connecting wires for example, **38**, **34**, the point **40** of mutual connection to radiator **4** will be of the same instantaneous polarity as brought out more clearly in Figure 9. The same polarity results from the phase change caused by the different physical lengths of the connecting wires. The far end of the radiating element is similarly connected to the ends of the legs of the loop L; and, in similar fashion, the ends of the radiators of the antenna A are terminated. In this case, wires **30** and **32** may be considered feeders and wires **26**, **38** neutralizers or vice versa, or, wire **30** may be considered a neutralizer, wire **34** a feeder, wire **38** a neutralizer and wire **26** a feeder or, the reverse. Because of the differences in length, wires such as wire **30** and wire **26**, should be properly chosen in size so that substantially equal heating currents will flow thereover.

I prefer Figure 4 for the reason that no chokes are required in the heating leads and for the reason that sleet melting is provided for neutralizers, feeders and the radiators, and, for the reason that there is no necessity for doubling up the radiator wires as is the case with modifications of my invention which will be described more fully hereinafter.

Another scheme for heating radiating elements, neutralizers and feeders is shown in Figure 5. Heating energy is supplied from a source **42**, switch **44**, transformers **46**, **48** and chokes **50** to the elements involved in the radiating system. In the upper position of switch **44**, heating energy is supplied over wires **52**, looped wire **54** having a looped portion as shown one-half wave length long and a straight portion **56** one-half wave length long and conductor **58**, one-half wave length long to radiators **2**, **4**. The heating circuit is completed by the wires forming feeders and neutralizers at the far end of the radiating element R. To heat feeder or neutralizer **60** and neutralizer or feeder **62**, switch **44** is thrown in the lower position as a result of which heating energy travels through transformer **48**, lower

chokes 50 and wires 64. The heating circuit is completed in this case also by the conductors terminating the far end of the radiating element R. The far end of the element is preferably counterweighted as indicated diagrammatictlly at points 66.

High frequency energy is supplied to the radiating element R over a transmission line T, impedance matching device D and line 68. Coupling of line 68 to wires 2, 4 is effected through, among other elements, condensers 70, 72 which effectively parallel wires 52 and 64 for high frequency currents. The apparatus shown within the dotted lines 74, namely, transformers 46, 48, chokes 50 and condensers 70, 72, may be located in the field; whereas, switch 44 should be placed at some more centrally located point.

The radiating element A is similarly energized to element R for radio frequency currents by means of line 76; and, for heating energy, by lines 78, 80 paralleling the secondaries of transformers 46, 48. Additional radio frequency chokes 82 may be placed in heating lines 78, 80.

As radiating element A is identical with radiating element R its detailed construction need not be given. Moreover, in view of the explanation given in connection with the antennae systems of Figures 3 and 4, the operation of the neutralizers and feeders for neutralizing radiation therefrom and for exciting radiating wires 2, 4, 6, 8 in proper phase need not be given, for it is thought that in view of the explanation referred to, the operation of the system of Figure 5 will be found self explanatory.

In the various embodiments of my invention so far described, the radiating wires of the radiating elements have been left in their original form. However, an efficient system allowing of heating of all of its members may be built up, as shown in Figures 6 and 7, by changing each wire to a plurality of wires effectively paralleled for radio frequency currents but serially connected for heating energy. Thus, in Figure 6 radiating wire 2 of radiating element R is made up of two wires 2', 4' connected together at their ends by jumper 10' and effectively paralleled for radio frequency currents by condensers 84. Wires 2', 4' comprising radiator 2 are serially connected at their near ends by loop 86. Condenser 88 acting as a short circuit for radio frequency currents causes the serial passage of heating energy through loop 86, wires 2', 4' and jumper 10'. Radiator 4 is similarly constructed.

High frequency energy flows from transmission line T, impedance matching device D, line 90, feeders 92, run parallel as far as possible for radiation neutralization to radiator 2, excitation taking place at a point intermediate its ends represented by condenser 88 which should be, with reference to the standing wave set up on radiator 2, a voltage nodal point. Radiator 4 is coupled in a similar fashion and, opposite phase excitation relative to that of radiator 2 is obtained by crossing feeder wires 92. The structure and excitation of the radiating element A is identical, the radio frequency supply being in this case through wires 94.

As jumpers 10' are connected across points of the same polarity, there is no radiation therefrom.

Heating energy is supplied from a source 96 to lines 90, 94, through lines 98, 100 having radio frequency chokes 102, 104 therein. In this manner it should be clear that the wires forming each radiator are effectively paralleled for radio frequency or high frequency currents and serially connected for heating energy.

Figure 7 indicates a preferred modification wherein wires are paralleled for radio frequency currents but wherein wires forming a radiator are paralleled for radio frequency currents and serially connected for heating energy. As the radiating elements are identical only one need be described. Referring to the radiating element R, each radiator 2, 4 consists of two wires 2', 4' and 6', 8', paralleled for radio frequency currents but serially connected for heating energy. The far ends of the wires are joined by jumpers 10' which are relatively short and produce no radiation as they are connected across points of like polarity. Transmission line 104' may be considered as a source of radio frequency energy having one terminal 106 connected through a conductor or path 108 one-half wave length long to wire 4'. Terminal 106 is connected to wire 8' through a path one wave length long which includes conductor 112 one-half wave length long and loop 114 one-quarter wave length long. Terminal 118 is connected to wire 6' of radiator 4 through a path one-half wave length long which path includes conductor 116. Terminal 118 of transmission line 104' is further connected through wire 120 and loop 110 one-half wave length long and one-quarter wave length long respectively to wire 2' of radiator 2. To insure parallel connection of the wires forming each radiator, condensers C may be connected thereacross. Insulators I and supporting elements 122 maintain the radiating element in proper elevated position.

A simplified wiring diagram of a radiating element of Figure 7 is shown in Figure 8, the reference numerals thereof correspond to the reference numerals applied to the element R of Figure 7.

Figure 9 is helpful in showing the phase change caused in radio frequency currents supplied over transmission line, for example, 104' to an antenna wire W over two paths a wave length long and a half wave length long respectively. It will be seen that the wire so connected has energy of the same polarity applied to it from both wires forming the supply transmission line.

Radio frequency current is derived primarily from a source S, transmission line T, branch lines B, impedance matching devices D to lines 104', 104, and thence through the feeders and loops to the radiators of each element. As in the case of the feeders and loops of the antennæ systems described hereinbefore, their close proximity and opposite polarity precludes detrimental radiation therefrom. As jumpers 10' are connected across points of the same polarity, there is no current flow therein and consequently no radiation.

Heating energy is supplied to the system shown in Figure 7 from a source of heating energy 16 over lines 20 and chokes 18 to the radiating elements A, R. The course of the heating current through the conductors of each radiating element is thought to be obvious from the wiring diagram of Figure 8 wherein the radiators 2, 4 act as parallel loads on the heating circuit.

Having thus described my invention, what I claim is:

1. An antenna system comprising radiating elements, each element comprising a pair of substantially parallel linear radiators joined together at both ends by connections, each connection

comprising a U-shaped loop having its legs connected to the radiators through paths mutually canceling radiation, said paths being a wave length long and one-half wave length long respectively.

2. An antenna system comprising radiating elements, each element comprising a pair of substantially parallel linear radiators, connections joining the ends of the radiators, each connection comprising a U-shaped loop having its legs connected to the radiators through non-radiating paths a wave length long and one-half wave length long respectively, a source of heating current connected to the hollows of both loops, and a source of high frequency current connected across the legs of one of the loops.

3. An antenna system comprising a radiating element comprising a pair of long linear radiating wires, a U-shaped wire loop coupled to a source of high frequency energy, one of the legs of the loop being connected to one of the wires through a connection one wave length long and to the other wire through a connection one-half wave length long, the other leg of the loop being connected in reversed fashion to the wires, similar connections at the other ends of the wires, and a source of low frequency energy coupled to the hollows of the U-shaped loops.

4. An antenna system comprising a radiating element, said element comprising a pair of radiators, said radiators comprising long linear parallel wires, a source of high frequency energy, a connection from one terminal of said source to one wire of one of said radiators, one-half wave length long and a connection from the other terminal of said source to the same wire of said one radiator one wave length long, said half wave length connection paralleling for a substantial part of its length a portion of said one wave length connection for neutralizing radiation therefrom, said remaining portion of said wave length connection being looped to prevent radiation from said remaining portion.

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