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2,276,497

ULTRA HIGH FREQUENCY ANTENNA FEEDBACK BALANCER

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Fig. 1

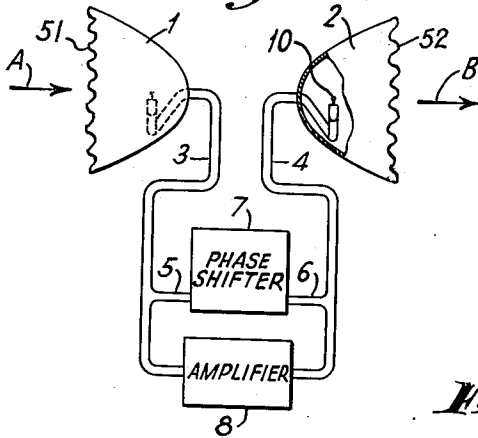


Fig. 2

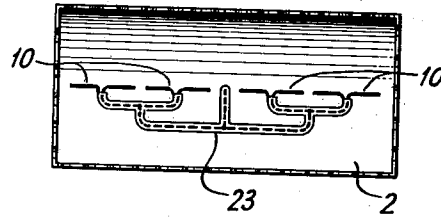


Fig. 3

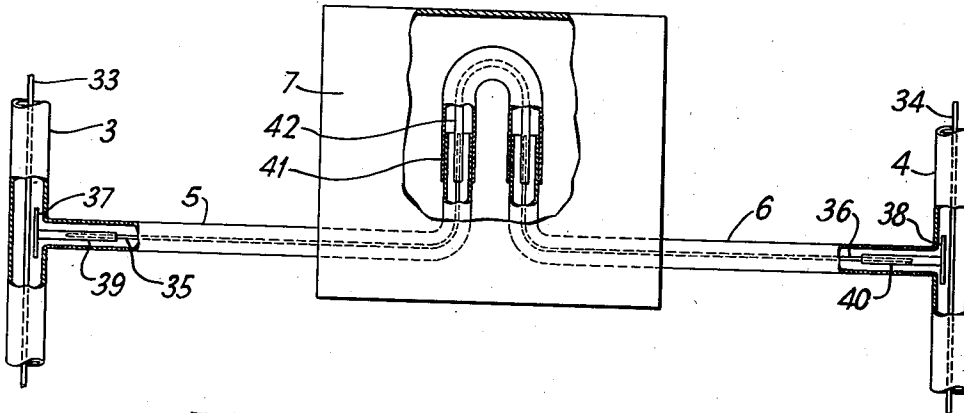


Fig. 4

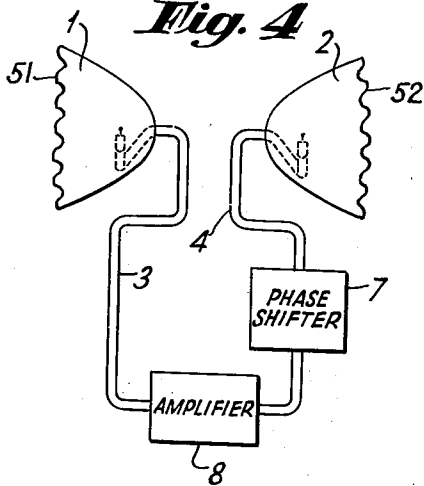
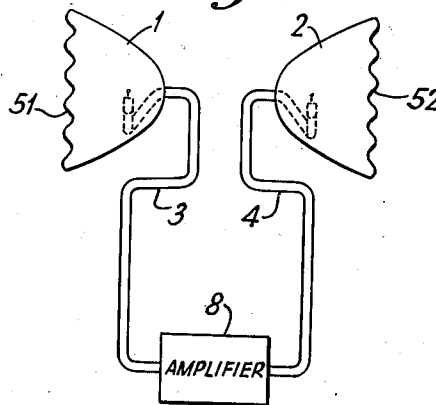


Fig. 5



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FEEDBACK BALANCERFred H. Kroger, Rocky Point, N. Y., assignor to
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13 Claims. (Cl. 250—15)

This invention relates to high frequency relay systems and, more particularly, to a means for enabling the relaying of an ultra high frequency radio signal without signal conversion.

In radio relaying by ultra high frequencies, it may be desirable to carry a radio signal along a chain of relay stations without resorting to frequency conversion. This may be done by receiving the incoming signal energy by an antenna on one supporting structure, amplifying and re-transmitting the signal from another antenna at some distance from the first at each relay location. Such an arrangement properly designed will have a feedback level low enough to preclude oscillations due to the re-radiated energy finding its way back into the receiving antenna. In a practical installation employing relay stations spaced 15 miles or more apart and having both receiving and transmitting antennas supported on the same tower at a convenient height above ground such as 100 feet, due to diffraction and re-radiation around the edges of the concentrating reflectors and other effects, isolation of the output and input energies may generally not be obtained without additional provisions. For this reason, I propose to introduce means neutralizing the feedback energy by introducing an additional component of predetermined magnitude and phase so as to counteract the extraneous feedback otherwise encountered.

An object, therefore, of the present invention is to enable the reception, amplification and re-transmission of a radio signal without resorting to signal conversion.

A further object of the invention is to receive, amplify and re-transmit ultra high frequency radio signals without frequency conversion.

Still another object of the invention is to compensate for extraneous feedback between the transmitting and receiving antennas of an ultra high frequency relay station.

Still another object of the invention is to compensate for extraneous feedback between the transmitting and receiving antennas of an ultra high frequency relay station in which the signal frequency is not converted.

Still a further object of the present invention is to provide means for introducing and regulating the magnitude and phase of a component of feedback energy between the transmitting and receiving antennas of an ultra high frequency relay station whereby the otherwise unavoidable feedback is counteracted or neutralized.

Still a further object of the present invention is to introduce a component of feedback energy

between the transmitting and receiving antennas of an ultra high frequency relay station of such magnitude and phase that the otherwise unavoidable feedback is counteracted or neutralized.

Referring, now, for a more complete understanding of the invention, to the following detailed description which is accompanied by a drawing in which Figure 1 illustrates a side view of an embodiment of the invention; Figure 2 shows an end view of a portion of my invention; Figure 3 is an enlarged detailed view of a portion of Figure 1 and Figures 4 and 5 illustrate further modifications of my invention.

Referring, now, to Figure 1, reference numerals 1 and 2 indicate the incoming and outgoing antennas. The two antennas are identical in construction as shown and consist of a metal reflecting surface in the shape of a cylindrical parabola with the end surfaces of metal, thus forming a box-like compartment or reflector within which is supported at the focus of the parabola the several dipole antennas which are shown in more detail in Figure 2. Connected to the receiving dipole antennas within reflector 1 is a concentric cable transmission line 3 which is connected to the input of a radio frequency amplifier 8. To the output of radio frequency amplifier 8 is connected a second concentric cable transmission line 4 which is in turn connected to the dipole antennas within reflector 2. The arriving signal, as indicated by the arrow A, is concentrated within reflector 1 on the receiving dipole antennas and transmitted by means of concentric cable 3 to the amplifier 8. The signal is thereafter amplified and sent out over transmission line 4 at the same frequency at which it was received and transmitted in direction B. The reflector 2 serves to concentrate the transmitted energy into a beam in the general direction shown by arrow B. The reflectors 1 and 2 may have their edges serrated as shown or the edges may be straight. The purpose of the serrations will be more fully described with reference to Figure 5. Between transmission lines 3 and 4 is connected a phase shifting means 7 by means of transmission lines 5 and 6. This structure is shown in an enlarged view in Figure 3 and will be described more fully with reference to that figure. Figure 2 shows an end view of the reflectors 1 or 2 shown in Figure 1. The reflectors are substantially identical in construction and it is believed unnecessary to show end views of each reflector separately. Within the reflector and at the focus of the parabola dipole antennas 10 are

supported. The antennas are coupled by means of the multi-branch transmission line 23 to the transmission line 3 on the exterior of the reflector.

While the coupling means 23 in Figure 2 is shown as being in a vertical plane it is to be distinctly understood that this is shown only for the purposes of clarity and it may be revolved about into a horizontal plane back of the dipoles and in the axis of the parabola. As a matter of fact, if desired, the coupling arrangement may be located exteriorly of reflectors 1 or 2 thus leaving merely the dipoles 10 in the reflectors.

Referring, now, to Figure 3 which shows in enlarged detail the phase shifting and coupling means for the feedback arrangement of Figure 1, transmission line 3 is seen to be composed of an outer sheath 3 and a central conductor 33. Likewise, the transmission line 4 is composed of an outer sheath 4 and a central conductor 34. Transmission line 5 contains an inner conductor 35 which passes through an aperture in the outer sheath of transmission line 3. The end of the conductor 35 nearest the conductor 33 carries a coupling conductor 37. This coupling conductor is adjustable in position with respect to conductor 33 by means of slip joint 39 on conductor 35, or any other suitable means may be employed. By means of this adjustable coupling arrangement the amount of energy fed back through transmission line 5 into feedback circuit may be adjusted. At the other end of the feedback circuit transmission line 6 is coupled to the central conductor 34 of transmission line 4 by means of a coupling conductor 38. A slip joint 40 carried by central conductor 36 of transmission line 6 is provided in order to vary the coupling between the conductor 34 and the conductor 36. The phase shifter 7 in the feedback circuit is here shown in partial section and comprises a box-like metallic shield 71 within which is located a trombone like slip joint connection between transmission lines 5 and 6. The ends of lines 5 and 6 are turned at right angles to run parallel to each other for a short distance within shield 71. A U shaped sheath 41 having a central conductor 42 is provided to be slid up and down over the ends of cables 5 and 6 thus effectively varying the total length of the conductor between the transmission line 4 and transmission line 3.

Since the energy level in transmission line 4 is higher than the energy level in transmission line 3 due to the amplification in amplifier 8, energy passes from transmission line 6 through 7 to 5 and thence back to the receiving transmission line 3. In operation, the following adjustments are necessary. The phase shifter 7 is adjusted by means of the slip joint arrangement shown in Figure 3 in order to give a minimum total resultant feedback which is a condition of the phase of the feedback energy through transmission lines 6 and 5 being 180 degrees out of phase with that fed back through external paths between reflectors 1 and 2. After this condition is attained the couplings between conductors 34 and 38 and 37 and 33 are adjusted by sliding slip joints 39 and 40 to give an amplitude of feedback neutralizing energy sufficient to exactly counterbalance the random fed back energy through the external paths. With the apparatus so adjusted the assembly is entirely stable and no oscillation or singing will be experienced.

In Figure 4 I have shown a modification of my invention which is somewhat simpler and, under some circumstances, may give satisfactory re-

sults. Normally, the energy received on the receiving antenna within reflector 1 due to leakage from the transmitting antenna within reflector 2 will have a random phase with respect to the output of amplifier 8. Therefore, by inserting a phase shifter 7 in the transmission line 4 the phase of the output 8 with respect to the phase of the received energy on the antenna within reflector 1 may be adjusted so as to cause the feedback to be regenerative or degenerative as desired. By causing the feedback to be slightly degenerative the amplifier 8 may be made stable. Construction of the phase shifter shown in Figure 4 may be exactly as shown in Figure 3.

In Figure 5 I have shown a means for reducing the feedback from the transmitting to the receiving antenna for a broad frequency band which in simple cases may be sufficient of itself to make the system stable. Experience has shown that the feedback encountered is greatly a function of frequency. With the usual situation of elevated antennas in open spaces the minor part of feedback is due to double reflection from objects nearby and the major part is due to radiation from the edges of the reflectors. The effectiveness of this radiation is dependent both upon the length of the periphery of the reflector, the orientation of the edges and the distance between the reflectors. As shown, by increasing the length of the edges of the reflector boxes from the normal by serrating them, the feedback due to radiation from the edges of the reflector box is reduced. In some cases it is not necessary to serrate the entire periphery of the reflector boxes but only a single cut in the edges may be necessary.

As a summary, it may be indicated that the possible sources of feedback energy and ultra short wave relay stations is, in general, limited to three main sources—(a) leakage directly from one antenna to the other; (b) re-radiation from the edges of the reflector and any adjacent metal parts, and (c) radiation by several reflections from objects in the vicinity of the supporting structure. Exhaustive tests indicate that the major part of the feedback energy is due to source above (b). Simply by soldering all the joints in the structure the feedback energy due to cause (a) above can be reduced to a negligible value. The distance of the adjacent objects from the antennas attenuates the energy reflected therefrom so as to normally cause it to be of only the second order of magnitude.

Ordinarily, the form of my invention shown in Figure 1 provides neutralization of feedback which is completely stable and applies to all types of communication where the feedback is of the type outlined in (b) above.

The form of my invention shown in Figure 4 is, perhaps, somewhat simpler and is just as effective where the feedback is a small fraction of the incoming signal, in which case it should be chosen for its simplicity.

While I have particularly shown and described several embodiments of my invention, it is to be clearly understood that my invention is not limited thereto but modifications may be made within the scope of the invention.

I claim:

1. A high frequency relay system comprising a receiving antenna, a reflector for concentrating received signals on said antenna, an amplifier having an input and an output, a first transmission line having an outer sheath and an inner conductor connecting said receiving antenna to

said input, a transmitting antenna, a reflector for concentrating energy radiated from said transmission line into a beam, a second transmission line having an outer sheath and an inner conductor connecting the output of said amplifier to said transmitting antenna, an auxiliary electrode within each of said transmission lines in adjustable relationship to said inner conductors and an auxiliary transmission line connecting said auxiliary electrodes, means for adjusting the length of said auxiliary transmission line whereby a small amount of energy of predetermined phase and amplitude is introduced into said first transmission line from said second transmission line.

2. A high frequency relay system comprising a pair of cylindrical parabolic reflectors, a plurality of dipole antennas in the focus of each reflector, an amplifier having an input and an output, a first transmission line having an outer sheath and an inner conductor connecting the dipole antennas in one of said reflectors to said input, a second transmission line having an outer sheath and an inner conductor connecting the dipole antennas in the other of said reflectors to the output of said amplifier, an auxiliary electrode within each of said transmission lines in adjustable relationship to said inner conductors and an auxiliary transmission line connecting said auxiliary electrodes and means in said auxiliary transmission line for varying the effective length of said line whereby a small amount of energy of predetermined phase and amplitude is introduced into said first transmission line from said second transmission line.

3. A high frequency relay system comprising a pair of cylindrical parabolic reflectors, a plurality of dipole antennas in the focus of each reflector, an amplifier having an input and an output, a first transmission line having an outer sheath and an inner conductor connecting the dipole antennas in one of said reflectors to said input, a second transmission line having an outer sheath and an inner conductor connecting the dipole antennas in the other of said reflectors to the output of said amplifier, an auxiliary electrode within each of said transmission lines in adjustable relationship to said inner conductors and auxiliary transmission line connecting said auxiliary electrodes, means for adjusting the length of said auxiliary transmission line whereby a small amount of energy of predetermined phase and amplitude is introduced into said first transmission line from said second transmission line, the edges of at least one of said reflectors being so formed that mutual coupling between the edges of the reflectors is reduced.

4. A high frequency relay system comprising a pair of cylindrical parabolic reflectors, a plurality of dipole antennas in the focus of each reflector, an amplifier having an input and an output, a first transmission line having an outer sheath and an inner conductor connecting the dipole antennas in one of said reflectors to said input, a second transmission line having an outer sheath and an inner conductor connecting the dipole antennas in the other of said reflectors to the output of said amplifier, an auxiliary electrode within each of said transmission lines in adjustable relationship to said inner conductors and an auxiliary transmission line connecting said auxiliary electrodes, means in said auxiliary transmission line for varying the effective length of said line whereby a small amount of energy of predetermined phase and amplitude is intro-

duced into said first transmission line from said second transmission line, the edges of each of said reflectors being so formed that mutual coupling between the edges of the reflectors is reduced.

5. A high frequency relay system comprising a pair of cylindrical parabolic reflectors, a plurality of dipole antennas in the focus of each reflector, an amplifier having an input and an output, a first transmission line connecting the dipole antennas in one of said reflectors to said input, a second transmission line connecting the dipole antennas in the other of said reflectors to the output of said amplifier, the edges of each of said reflectors being serrated whereby the effective length of the periphery of each of said reflectors is increased.

6. A high frequency relay system comprising a pair of cylindrical parabolic reflectors, a plurality of dipole antennas in the focus of each reflector, an amplifier having an input and an output, a first transmission line connecting the dipole antennas in one of said reflectors to said input, a second transmission line connecting the dipole antennas in the other of said reflectors to the output of said amplifier, an auxiliary transmission line connecting said first and second transmission lines whereby a small amount of energy of predetermined phase and amplitude is introduced into said first transmission line from said second transmission line, the edges of each of said reflectors being serrated whereby the effective length of the periphery of each of said reflectors is varied.

7. A high frequency relay system comprising a pair of cylindrical parabolic reflectors, a plurality of dipole antennas in the focus of each reflector, an amplifier having an input and an output, a first transmission line having an outer sheath and an inner conductor connecting the dipole antennas in one of said reflectors to said input, a second transmission line having an outer sheath and an inner conductor connecting the dipole antennas in the other of said reflectors to the output of said amplifier, an auxiliary electrode within each of said transmission lines in adjustable relationship to said inner conductors and an auxiliary transmission line connecting said auxiliary electrodes, means for adjusting the length of said auxiliary transmission line whereby a small amount of energy of predetermined phase and amplitude is introduced into said first transmission line from said second transmission line, the edges of each of said reflectors being serrated whereby the effective length of the periphery of each of said reflectors is increased.

8. A high frequency relay system comprising a pair of cylindrical parabolic reflectors, a plurality of dipole antennas in the focus of each reflector, an amplifier having an input and an output, a first transmission line having an outer sheath and an inner conductor connecting the dipole antennas in one of said reflectors to said input, a second transmission line having an outer sheath and an inner conductor connecting the dipole antennas in the other of said reflectors to the output of said amplifier, an auxiliary electrode within each of said transmission lines in adjustable relationship to said inner conductors and an auxiliary transmission line connecting said auxiliary electrodes and means in said auxiliary transmission line for varying the effective length of said line whereby a small amount of energy of predetermined phase and amplitude is introduced into said first transmission line from

said second transmission line, the edges of each of said reflectors being serrated whereby the effective length of the periphery of each of said reflectors is increased.

9. A high frequency relay system comprising a pair of cylindrical parabolic reflectors, a plurality of dipole antennas in the focus of each reflector, an amplifier having an input and an output, a first transmission line having an outer sheath and an inner conductor connecting the dipole antennas in one of said reflectors to said input, a second transmission line having an outer sheath and an inner conductor connecting the dipole antennas in the other of said reflectors to the output of said amplifier, an auxiliary electrode within each of said transmission lines in adjustable relationship to said inner conductors and an auxiliary transmission line connecting said auxiliary electrodes, means for adjusting the length of said auxiliary transmission line whereby a small amount of energy of predetermined phase and amplitude is introduced into said first transmission line from said second transmission line.

10. A relay system comprising a receiving antenna and a transmitting antenna each including wave directive structure, said antennas being directed in different directions, amplifying means having an input coupled to said receiving antenna and an output coupled to said transmitting antenna, the edges of said wave directive structure being serrated whereby the peripheral length thereof is increased.

11. A relay system comprising a receiving antenna and a transmitting antenna each including wave directive structure, said antennas being directed in different directions, amplifying means having an input coupled to said receiving antenna and an output coupled to said transmitting antenna, the edges of at least one of said wave directive structures being serrated whereby the peripheral length thereof is increased.

12. A high frequency relay system comprising a pair of parabolic reflectors, an antenna in the focus of each reflector, an amplifier having an input and an output, a first transmission line connecting the antenna in one of said reflectors to said input, a second transmission line connecting the antenna in the other of said reflectors to the output of said amplifier, the edges of each of said reflectors being serrated whereby the effective length of the periphery of each of said reflectors is increased.

13. A high frequency relay system comprising a pair of parabolic reflectors, an antenna in the focus of each reflector, an amplifier having an input and an output, a first transmission line connecting the antenna in one of said reflectors to said input, a second transmission line connecting the antenna in the other of said reflectors to the output of said amplifier, the edges of at least one of said reflectors being serrated whereby the effective length of the periphery thereof is increased.

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