

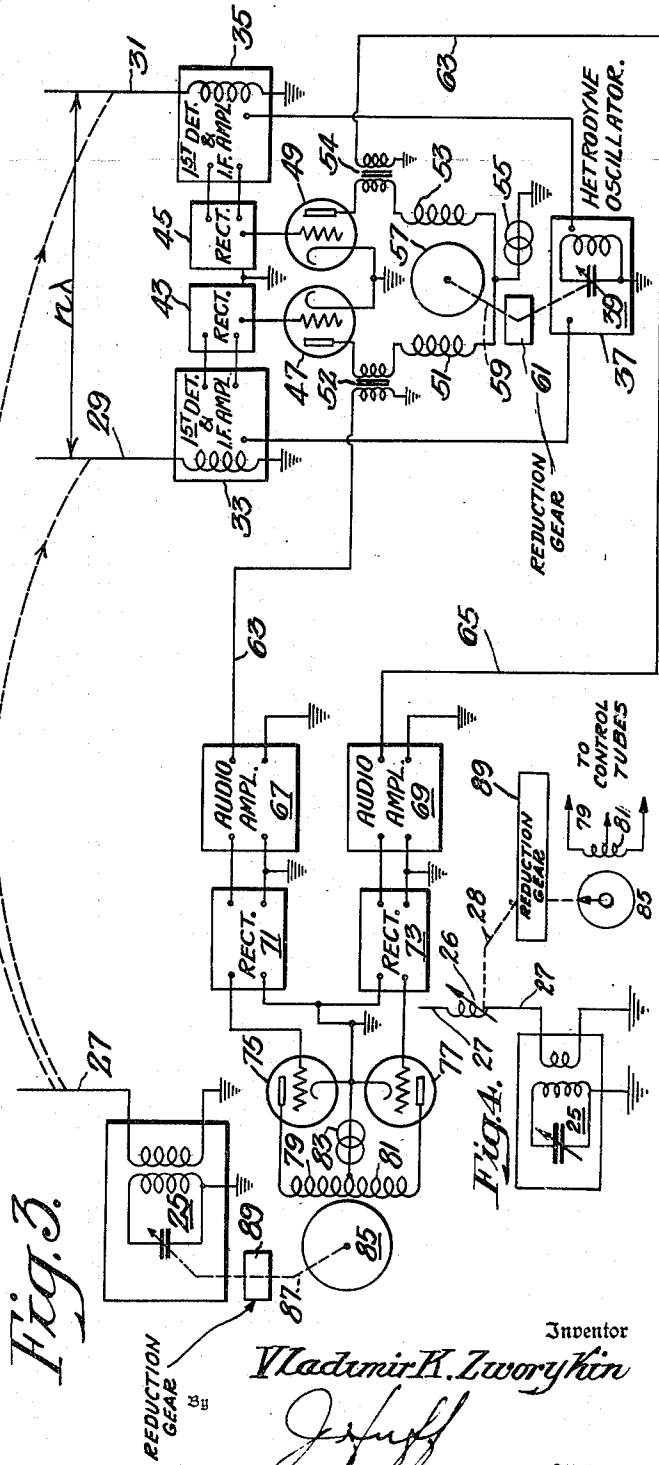
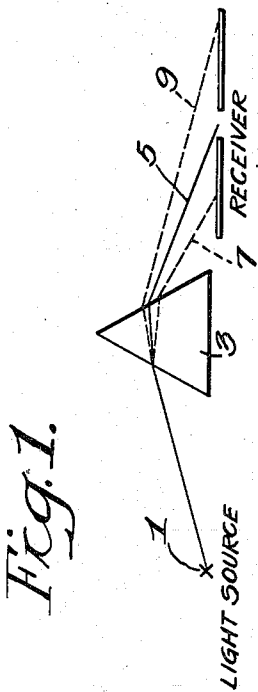
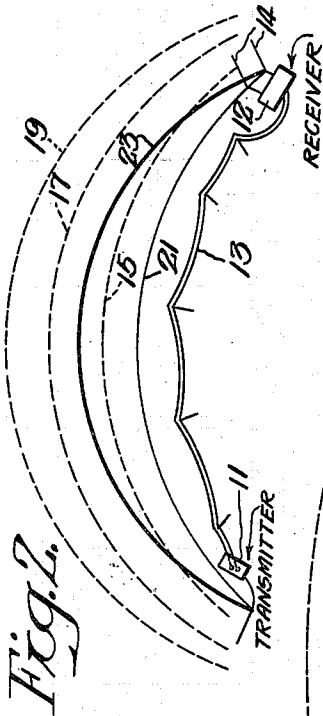
Aug. 9, 1938.

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2,125,977

ULTRAHIGH FREQUENCY RADIO SYSTEM

Filed July 18, 1936



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UNITED STATES PATENT OFFICE

2,125,977

ULTRAHIGH FREQUENCY RADIO SYSTEM

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Application July 18, 1936, Serial No. 91,371

11 Claims. (Cl. 250—11)

My invention relates to ultra high frequency radio systems. More specifically my invention is a system for transmitting ultra high frequency waves over distances greater than the line of sight between the transmitter and receiver.

By ultra high frequency waves is meant waves whose oscillatory frequency is of the order of thirty megacycles and upward. Until recently it has been assumed that ultra high frequency waves are propagated within the line of sight of the transmitter, and that atmospheric diffraction of ultra high frequency was negligible. However, those skilled in the art have recognized numerous cases of anomalous propagation of ultra high frequency waves.

Transmission of ultra high frequency waves beyond the line of sight may be best explained by refraction, reflection or like effects of the atmosphere. My invention contemplates making use of such reflection or refractions to transmit ultra high frequency waves over considerably greater distances than the line of sight from the transmitter.

One of the objects of my invention is to provide means for monitoring an ultra high frequency transmitter at a point remote from the line of sight to thereby maintain a substantially constant signal at the remote point. Another object is to provide means for automatically adjusting the frequency of an ultra high frequency transmitter to maintain a substantially constant field strength beyond the optical horizon of the transmitter. A further object is to provide means for altering the direction of propagation of an ultra high frequency wave by suitably directing waves of the proper frequency to a reflecting region in the atmosphere.

In the accompanying figures, Figure 1 is a schematic illustration of light waves which are refracted by a prism,

Figure 2 is a schematic illustration of the transmission and monitoring system of my invention,

Figure 3 is a circuit diagram of one embodiment of my invention, and

Figure 4 is a modified diagram of the means for varying the angle of radiation of the transmitter.

Referring to Fig. 1, if a source beam of light from a monochromatic source 1 is transmitted through an optical prism 3, the light waves will be bent as indicated by the unbroken line 5. If the frequency of the waves from the light source is increased, the bending of the light in the prism, i. e., the angle of refraction, is likewise increased and the light waves follow the dash line 7. If, however, the frequency of the light waves is de-

creased, the angle of refraction is decreased and the waves follow the dash line 9.

While radio waves of ultra high frequency do not exactly follow the analogy of optics, the action of regions of the atmosphere on ultra high frequency waves has an effect somewhat similar to the effects of optical prisms, reflectors and the like on light waves. The bending of radio waves by reflection or refraction is not constant but may vary with respect to time due to changing atmospheric or climatic conditions. It is well known to those skilled in the art that ultra high frequency waves propagated over long distances are rarely constant, but vary with time, frequency of the wave, and other factors.

In Fig. 2 are shown a transmitter 11 for the propagation of ultra high frequency waves, and a receiver 12. The receiver is represented with a pair of antennas 14 which are spaced some distance apart. The transmitter and receiver are connected by a pair of lines 13 on which are transferred the monitoring signals. Regions of the atmosphere are represented by the dash lines 15, 17, and 19. The earth's surface is indicated by the curved line 21. The radio wave transmission path is shown as a heavy line 23. It should be understood that the transmission path may be caused by reflection, refraction, bending, or combinations thereof, and the curved path is merely by way of illustration, as the actual path may be much more complicated.

Since the field strength at the receiver will vary with the variations in the transmitted wave length, transmission path, or ionized regions or portions of the atmosphere, it becomes necessary to concomitantly vary the wave length of the transmitter and receiver to maintain constant signals. That is, since it is not practical to consider maintaining the required ionization region, I propose to adjust the wave length to obtain the required bending from the ionized region as it may exist.

The field strength at a pair of suitably positioned receiving antennas varies with the transmission path, i. e., one antenna may receive more or less energy than the other at any instant. The difference in signal strengths may be used to initiate a monitoring signal which will simultaneously adjust the wave length at receiver and transmitter to thereby maintain the frequencies which afford the optimum transmission path. Thus, by monitoring at the receiver, a condition of constant field strength may be maintained between the receiving antennas. The monitored received signals of constant strength may be used

as a relay to modulate a second transmitter, not shown, or for normal long distance reception.

The transmitter and receiver may be connected by a pair of ordinary telephone lines or low frequency radio channels. The question of the utility of the foregoing arrangement is readily answered by considering the relative cost of a concentric cable for transmitting a wide band of frequencies, such as are used in television, between the transmitter and receiver. The proposed system is suitable for transmission over large bodies of water, mountains, and other regions where a concentric cable would be impractical.

One of the necessary elements of my system is in the means for automatically increasing or decreasing the frequency of the transmitter, or the angle of radiation from the transmitting antenna, to thereby obtain the optimum transmission path between transmitter and receiver. Since a number of means may be used for automatically monitoring the transmitter, the system disclosed in Fig. 3 is to be taken as illustrating one embodiment of my invention. In Figure 3 the tunable circuit 25 is energized by thermionic tubes or the like. The tunable circuit is coupled to an antenna system 27. The antenna may be adjusted to any desired angle of radiation with respect to the earth's surface so that the waves reflected by regions of the atmosphere are received by receiving antennas 29, 31. The antennas 29, 31 are preferably spaced a plurality of wave lengths apart, i. e., $n\lambda$.

The antennas 29, 31 are respectively coupled to first detectors and intermediate frequency amplifiers 33, 35. A local heterodyne oscillator 37, which includes a tunable circuit 39, is coupled to the first detectors to establish the intermediate frequency currents. The intermediate frequency currents are amplified and rectified by suitable rectifiers 43, 45. The output of these rectifiers is used to bias, preferably to cut off, a pair of control tubes 47, 49. The output circuits of these tubes include a pair of field windings 51, 53, transformers 52, 54 and a source of alternating current 55. The field windings are arranged so that each tends to oppositely rotate the rotor 57 of a synchronous motor. The shaft 59 of the motor is connected through suitable speed reducing gears 61 to the rotor shaft of the variable element of the tunable circuit 39 of the heterodyne oscillator.

Each of the output circuits of the transformers 52, 54 are respectively coupled to transmission lines 63, 65. The transmission lines are connected to audio frequency amplifiers 67, 69 at the transmitting station. The amplifiers 67, 69 at the transmitter overcome losses in the transmission lines. The outputs from the last mentioned amplifiers 67, 69 are respectively rectified by rectifiers 71, 73. The rectified output is used to control the input bias of a pair of control tubes 75, 77. A pair of field windings 79, 81 and a source of alternating current 83 are included in the output circuits of the control tubes. The frequency of the alternating currents at the transmitter and receiver is preferably the same. The field windings 79, 81 tend to oppositely rotate the rotor 85 of a synchronous motor. The shaft 87 of the synchronous motor is coupled to a reduction gear 89 whose ratio is similar to the reduction gear 61 at the receiver. The reduction gear 89 is in turn connected to the variable element of the tunable circuit 25.

The operation of the system is essentially as

follows: The transmitter frequency and angle of radiation are adjusted to give substantially equal signal strengths at the receiving antennas 29, 31. The currents induced in the antennas are equally amplified by the pairs of intermediate frequency amplifiers at both receiver and transmitter. The amplified intermediate frequency currents are rectified at the receiver and the audio frequency currents are amplified and rectified at the transmitter. The rectified currents bias both pairs of control tubes 47-49 and 75-77 to substantially cut off the output currents of the control tubes. Since the field windings are arranged to turn the rotors in opposite directions, and since the output currents are either zero or balanced, the rotors 57 and 85 do not turn in either direction.

A change in the transmission path caused by variations in bending, reflecting, or refracting will vary the field strength at the receiving antennas. Suppose that one (29) of the antennas receives no signal in the associated receiver, there will be no rectified currents, and no biases for the control tubes (47, 75). Therefore, alternating current will flow in the associated field winding 51 and transformer 52. The low frequency currents in the transformer 52 will be conveyed through the transmission line 63 to the amplifier 67 at the transmitter. The amplified low frequency currents are rectified. The rectified currents establish biasing voltages on the grid of the control tube 75 which permit current to flow in the field winding 79 and thereby energize the motor. The other antenna (31) will receive normal or above normal currents, and the field winding 53 and transformer 54, associated with such antenna through the control tubes, rectifiers, amplifiers, and first detectors, will not be energized. Thus the synchronous motor rotors 57 and 85, each under the influence of a single or unbalanced field, will be operated to both vary the tunable units of the tuned circuits 25 and 39.

If the antenna 29 nearer the transmitter has received weak or substantially no signals, the rotors 57 and 85 are started simultaneously and operate synchronously. The rotation of the rotors, acting through the reducing gear, is arranged to simultaneously and synchronously increase the transmitted frequency and the corresponding resonance of the receivers. As the frequency is increased, the path of propagation will be quickly altered, until the receiving antennas are once more equally responsive. At the moment of equal response, the synchronous motors stop, thereby locking the receiver and transmitter in resonance, but ready to automatically repeat the foregoing cycle or a corresponding cycle in the reverse direction.

An alternate method of operation may be employed as follows: Instead of altering the frequency of the transmitter and receiver to obtain the optimum path of propagation, the angle of radiation of the transmitting antenna may be adjusted to obtain similar effects by varying a sectionalizing inductance in the antenna 27 as disclosed in U. S. Patent No. 2,068,261, which issued to G. H. Brown on January 19, 1937. The variation of the antenna inductance 25 may be accomplished by a connection 28 from the reduction gear 89 as shown in Fig. 4. The balance of the circuit is shown in Fig. 3. If the angle of radiation is adjusted, I prefer to employ an antenna array for transmitting a beam of ultra high frequency waves. If the angle of the antenna with respect to the earth is varied, the reflected or

bent wave may be maintained constant at the monitoring receiver by omitting the field windings 51, 53, rotor 57 and connected gears 61. The receiver is operated at constant frequency.

The monitoring signals, after conversion to low frequency currents, are transmitted through the transmission lines. The rotor of the motor at the transmitter is operated as before, but is connected through suitable gearing, levers, and the like to vary the angular position of the antenna 27. It should be understood that a relatively small change in angle will greatly change the transmission path. This latter method is analogous to varying the angle of a beam of light, which is reflected by a mirror whose position is being varied above the earth, to maintain constant light at a remote point. The connection between the speed reducing gears 89 and variable element of the tuned circuit 25 is omitted because both transmitter and receiver are operated at constant frequency.

Thus I have described an ultra high frequency system in which the desired wave propagation is reflected from an ionized region or portion of the atmosphere. A pair of receiving antennas, spaced a plurality of wave lengths apart, receive the reflected wave and automatically monitor the transmitter. The transmitter is thus automatically adjusted to transmit waves of the frequency, which affords optimum reflection from regions of the atmosphere. Instead of altering the frequency to maintain the required reflection or bending of the waves, the angle of radiation may be adjusted to maintain the optimum path of wave propagation between transmitter and receiver. Although I have indicated a tunable receiver, which is automatically tuned to the transmitter, it should be understood that the automatic tuning of the receiver may be dispensed with if a broadly tuned receiver is employed at the monitoring station.

I claim as my invention:

1. An ultra high frequency system comprising in combination, an ultra high frequency transmitter, a pair of receiving antennas, a pair of receivers connected to said antennas, means for altering the path taken by said waves between said transmitter and said receiving antennas in accordance with differences in currents impressed by the transmitter on said antennas, and means for impressing said differences in received currents on said means for altering said path of the transmitted wave.

2. An ultra high frequency system comprising in combination, an ultra high frequency transmitter, a pair of receiving antennas located beyond the optical horizon of the transmitter, a pair of receivers connected to said antennas, means for altering the propagation of waves from said transmitter in accordance with differences in currents impressed by the transmitter on said antennas, and means for impressing said differences in received currents on said means for altering said propagation of the transmitted wave.

3. An ultra high frequency system comprising in combination, an ultra high frequency transmitter, a pair of receiving antennas spaced a plurality of said transmitted wave lengths apart, a pair of receivers connected to said antennas, means for altering the propagation of waves from said transmitter in accordance with differences in currents impressed by the transmitter on said antennas, and means for impressing said differences in received currents on said means for altering said propagation of the transmitted wave.

4. An ultra high frequency system comprising in combination, an ultra high frequency transmitter, a pair of receiving antennas located beyond the optical horizon of the transmitter and spaced a plurality of said transmitted wave lengths apart, a pair of receivers connected to said antennas, means for altering the propagation of waves from said transmitter in accordance with differences in currents impressed by the transmitter on said antennas, and means for impressing said differences in received currents on said means for altering said propagation of the transmitted wave.

5. An ultra high frequency system comprising a transmitter of ultra high frequency waves, means for varying the frequency of said waves to effect optimum reflection or refraction from a region in the atmosphere, a pair of antennas for receiving said waves, and means coupling said antennas with said frequency varying means so that differences in received currents will automatically adjust the frequency to effect equality of received currents.

6. An ultra high frequency system comprising a transmitter of ultra high frequency waves, means for varying the frequency of said waves to effect optimum propagation to a point beyond the optical horizon of said transmitter, a pair of antennas for receiving said waves at said point, means for amplifying said received waves, and means for impressing the amplified waves on said frequency varying means so that the frequency of the transmitted wave is automatically varied to effect a substantially constant field strength at said point.

7. An ultra high frequency system comprising a transmitter of ultra high frequency waves, means for varying the angle of radiation of said waves to effect optimum propagation, a pair of antennas for receiving said waves, and means coupling said antennas with said angle of radiation varying means so that differences in received currents will automatically adjust said angle to effect equality of received currents.

8. An ultra high frequency system comprising a transmitter of ultra high frequency waves, means for varying the angle of radiation of said waves to effect optimum propagation to a point beyond the optical horizon of said transmitter, a pair of antennas for receiving said waves at said point, means for amplifying said received waves, and means for impressing the amplified waves on said angle of radiation varying means so that said angle of radiation of the transmitted wave is automatically varied to effect a substantially constant field strength at said point.

9. In a device of the character of claim 6, means for automatically adjusting the amplifying means at the receiver to a condition responsive to changes in the transmitter frequency.

10. The method of transmitting ultra high frequency waves beyond the line of sight of a transmitter to remote receivers which comprises adjusting the frequency of the transmitted wave to effect reflection from a region of the atmosphere, receiving said reflected wave on a remotely located pair of receivers, converting said received wave to low frequency currents transmitting said low frequency currents to the transmitter, and utilizing differences in said low frequency currents to control means for altering the transmitter frequency to effect substantially equal reflection of the transmitted waves from said region to said receivers.

11. The method of transmitting ultra high fre-

quency waves from a transmitter to a pair of remotely located receivers beyond the line of sight from said transmitter which comprises adjusting the angle of radiation of said transmitter to effect substantially equal reflection from a region of the atmosphere to said receivers, amplifying said received waves, converting said received waves to low frequency currents, transmitting

said low frequency currents to said transmitter, and utilizing any differences in said low frequency currents to control means for varying the angle of radiation of said transmitter to effect substantially equal propagation of said waves to said pair of receivers.

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