Sept. 19, 1939. E. G. LINDER 2,173,234

RADIO APPARATUS

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Fig. 1.

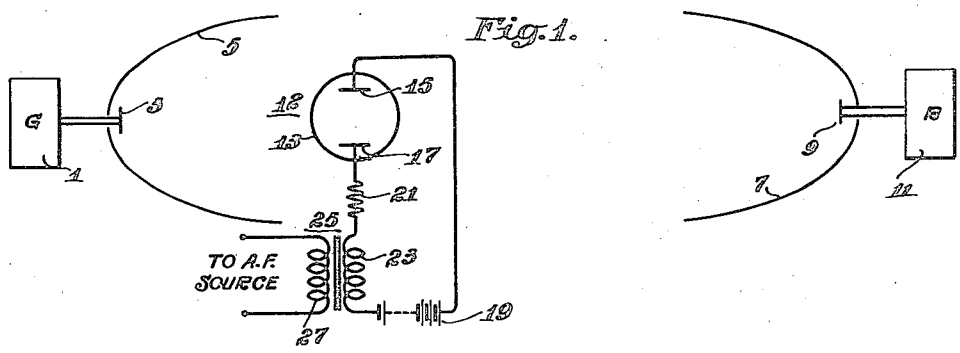
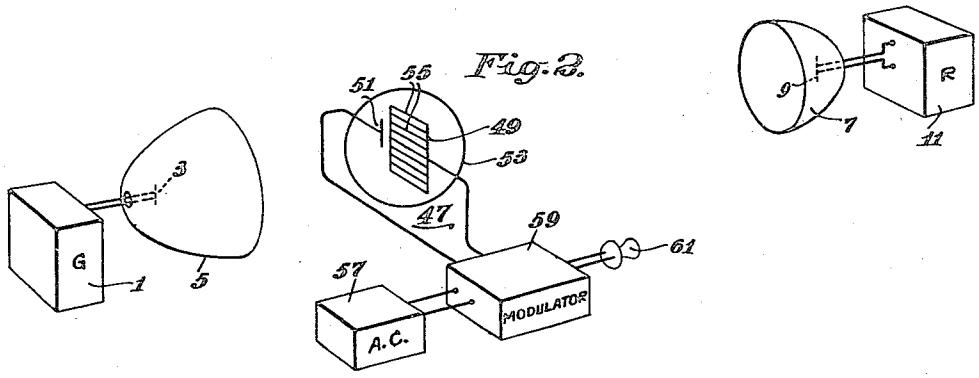


Fig. 2.



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Fig. 3.

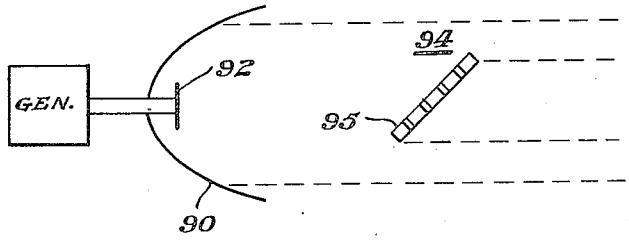


Fig. 4.

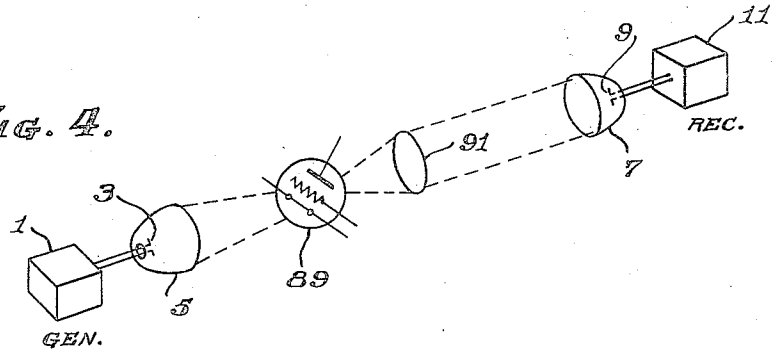


Fig. 5.

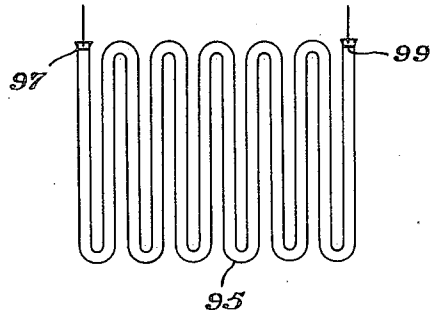
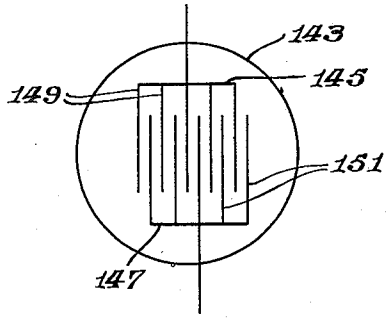


Fig. 6.



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UNITED STATES PATENT OFFICE

2,173,234

RADIO APPARATUS

Ernest G. Linder, Philadelphia, Pa., assignor to Radio Corporation of America, New York, N. Y., a corporation of Delaware

Original application August 31, 1933, Serial No. 687,544. Divided and this application June 9, 1936, Serial No. 84,263

8 Claims. (Cl. 179—171.5)

My invention relates to radio apparatus and particularly to means for modulating radio energy having a short wave length.

This application is a division of my co-pending application Ser. No. 687,544, filed August 31, 1933 which issued as Patent No. 2,047,930 on July 14, 1936.

While there are many advantages in the use of such radio energy, it is difficult to modulate it to the desired degree without changing its wave length. In other words, instead of obtaining a pure amplitude modulation, both amplitude and frequency modulation are obtained.

It is also difficult to receive radio energy having a very short wave length because a slight variation in the frequency of the received energy prevents the energy from passing through the tuned circuit of the receiver.

It has been discovered that the difficulty in modulating such energy can be overcome by intercepting the path of the radio waves by means of a device which is electrically independent of the high frequency generator and by varying the electrical or mechanical characteristics, or both, of this device in accordance with a signal. Such a system is described and claimed in U. S. Patent 2,078,302, which issued on April 27, 1937, on application of Irving Wolff, Ser. No. 687,599, filed August 31, 1935, and assigned to the same assignee as this application.

An object of my invention is to provide an improved method and means for modulating high frequency radio energy in a system of the above-mentioned type.

More specifically, an object of my invention is to provide an improved method and means for providing a high percentage of modulation of radio energy at very short wave lengths without producing frequency variations therein.

A further object of my invention is to provide an improved means for transmitting a sharp beam of modulated radio energy.

In practicing my invention, I improve upon the system disclosed in the above-mentioned Wolff patent by interposing a region of free electric charges in the path of a radio wave in such a manner that reflections from this region back into the generator are reduced, and controlling a condition of said region in accordance with a signal, whereby the radio wave is modulated. Specifically, I prefer to interpose a region of ionized gas in the path of the radio wave and to vary the degree or character of ionization in accordance with a signal.

Other features and advantages of my invention will appear from the following description when taken in connection with the accompanying drawings in which

Figure 1 is a schematic diagram illustrating the principle of my invention which is described and claimed in the above identified application of which this is a division;

Figure 2 is a schematic diagram illustrating an embodiment of my invention for preventing undesired reflections;

Figures 3 and 4 are schematic diagrams illustrating modified forms of my invention; and

Figures 5 and 6 are views showing alternative forms of modulating devices which may be utilized in practicing my invention.

The principle of the invention, claimed in the above mentioned copending application and illustrated in Fig. 1, comprises a high frequency generator 1, such as a magnetron oscillator, electrically connected to a dipole antenna 3 located inside a parabolic reflector 5. The energy radiated by the antenna 3 is directed into the form of a beam by the reflector 5 and is transmitted to a receiving reflector 7 which has a dipole antenna 9 located therein and connected to a radio receiver 11.

In the past it has been customary to signal over such a radio beam by modulating the high frequency energy at the generator itself, in which case the modulated radio energy is impressed upon the transmitting antenna. It is difficult to obtain a radio beam of constant low wave length having amplitude modulation, for the reason that it has been found in practice that the modulating device at the generator may cause the frequency of the generator output wave to change.

In accordance with the above-mentioned invention, I pass the radio beam through the electric discharge of a modulating device 12 positioned in the path of the radio beam and electrically independent of the high frequency generator. This device comprises an envelope 13 filled with a gas, such as one of the noble gases, which can readily be ionized.

Electrodes 15 and 17 are positioned inside the envelope 13 and are connected to a source of ionizing potential 19 through a resistor 21 and the secondary 23 of an audio or modulation signal frequency transformer 25, the resistor 21 being provided to limit the flow of current through the ionized gas. The primary 27 of the audio frequency transformer 25 is connected to the source of modulating current which is indi-

ated on the drawings as being an audio frequency source.

By means of this circuit, the gas in the envelope 13 is maintained constantly ionized by he direct current potential of source 19, while he degree of ionization is varied in accordance ith the modulating voltage appearing across the econdary 23. I have found that such a device ill produce an undistorted modulated radio eam at the receiver. For example, if voice curents are put through the primary 27, the voice an be heard at the receiver in its original undisorted form.

The modulating device 12 may be positioned o intercept the radio beam at any point, although obviously the preferred position is relatively close to the transmitter reflector 5. If deired, the envelope may be placed inside the ransmitter reflector, itself.

The modulating effect caused by the ionized as is due to various properties of the gas. The nodulating voltage varies the density and disribution of ionization within the envelope and ence the electrical and optical properties of the as, such as dielectric constant, conductivity, coefficient of absorption, coefficient of reflection, iffuse scattering, temperature, etc.

The above described apparatus provides subtantially pure amplitude modulation. The staility of the transmitter is much better than that of the usual short wave transmitter since the oscillating circuit of the generator is not seriously interfered with. In fact, the only interference with the oscillating circuit is that produced by the small amount of energy which may be reflected from the ionized gas back into the reflector. This reflected energy may vary the load on the antenna slightly. It is the purpose of this invention to prevent this undesired reflection.

Where a plane of ionized gas is utilized for modulating, the energy reflected therefrom may be prevented from reaching the transmitter reflector by setting the modulating reflector at an angle to the axis of the radio beam, as explained in the above-identified Wolff patent and illustrated by the angular disposition of the modulating devices of Figs. 3 and 4.

In the embodiment shown in Fig. 2, the receiving and transmitting apparatus of Fig. 1 is shown in connection with a modulating means in which the ionized gas device 47 has two electrodes 49 and 51 so arranged that a plane of ionized gas is formed inside the envelope 53. The plane of the ionized gas coincides with the plane of the electrode 49. Preferably the spacing between the grid wires 55 of the electrode 49 is small in comparison with the wave length of the radio beam, and the gas pressure is such that the Crookes dark space is small in comparison with the spacing between the grid wires 55.

The function of the grid-like electrode 49 of Fig. 2 is to provide an electrode surface which will permit the passage of polarized ultra high frequency radio energy without undue absorption. An electric discharge within a gaseous medium having the proper pressure, potential, etc., does not follow the shortest path, but covers the entire electrode surfaces. The position of electrode 51 is relatively unimportant and simply provides the necessary terminal to effect the required plane of ionized electric discharge about electrode 49.

Ionization may be maintained by means of current having a super-audible frequency. A super-audible frequency generator indicated at 57 is connected to a modulator 59 which may be of any of the well known designs. The modulating frequency may be supplied from a microphone 61 connected to the modulator 59. If desired, the ionizing and modulating potentials may be applied to the electrodes 49 and 51 by means of either the circuit shown in Fig. 1, in which case the electrode 49 is negative, being connected to the negative terminal of the direct current source.

When using a grid composed of wires as one electrode, as illustrated in Fig. 2, certain precautions must be taken to insure proper operation of the device. It is well known that a transmitter of the type shown generates a radio beam which is strongly polarized in the plane of the dipole antenna 3, for example, in a vertical plane. Since the grid wires 55 are spaced closer together than one wave length, they will act as a reflector, substantially the same as a solid sheet of metal, if they are placed so that they run parallel to the plane of polarization. This difficulty can be avoided by so placing the electrode 49 that the closely spaced wires 55 are perpendicular to the plane of polarization, or in the example given, placed so they are horizontal.

In Fig. 3, there is illustrated an embodiment of my invention which makes possible the transmission of a sharply defined modulated beam of radio energy without troublesome reflections. When forming a beam of radio energy even at wave lengths of a few centimeters, it is difficult to obtain a beam of small cross-section which is sharply defined since the wave length is not extremely small in comparison with the reflector dimensions as in the case of light.

In the apparatus shown in Fig. 3, the reflector, indicated at 90, is made large enough to sharply define the energy radiated from the dipole antenna 92. The resulting beam necessarily has a fairly large cross-section so that the location of the receiving reflector need not be very exact to receive part of the beam. This may be undesirable in some instances, as in the case of secret signaling.

Therefore, instead of modulating the entire beam, I position one of my ionized gas modulating devices 94 in the path of a portion of the radio beam. It is placed at an angle to the axis of the beam so that any energy which is reflected from the modulating electrode will be directed away from the reflector 90. The device 94 will cast a modulated shadow which will be smaller in cross-section than the beam itself and will, in effect, give a sharper radio beam.

The device 94 is of a type which modulates by absorption, reflection, and/or scattering, that is, it should not be a type which disperses the beam. The device 94 illustrated in Fig. 3 is shown in detail in Fig. 5. It comprises a long gas filled tube 95 bent back and forth upon itself to form a rectangular grid. Electrodes 97 and 99 are provided at each end of the tube 95 by means of which the gas may be ionized. The spacing between adjacent portions of the tube 95 should preferably be relatively close and in any case less than one wave length of the radio beam.

Instead of the device shown in Fig. 5, either the one shown in Fig. 2 or the one shown in Fig. 6 may be utilized.

The latter device comprises a gas filled envelope 143 in which electrodes 145 and 147 have interleaving elements 149 and 151, respectively.

The elements 149 and 151 may be in the form of rods, all positioned in the same plane. It is apparent that with this structure, the plane of ionized gas coincides with the plane of the electrodes 145 and 147.

Fig. 4 illustrates an embodiment of my invention in which a three element discharge tube modulator 89 is placed at an angle to the focused beam from the reflector 5 so that energy reflected by the modulating device is prevented from returning to the source 1.

My invention is not restricted to the use of an ionized gas discharge. Any other type of discharge may be employed which provides a region containing free electrical charges. For example, the use of a glow discharge, a corona discharge, a spark discharge, a pure electron discharge, a pure positive ion discharge, comes within the scope of my invenetion. Also, it is obvious that ionization of the gas may be produced by agencies other than those illustrated. For example, I may ionize the gas of a modulating tube by means of ultra violet light, X-rays, heat, or any combination of these.

The nature of the gas employed in the various modulating devices described may vary widely. Either pure gases or gas mixtures may be employed, but preferably noble gases are used. The gas pressure may vary from zero, where there is a pure electron discharge, up to the highest pressure at which a discharge can be produced. It will be understood that the pressure of the gas in tubes such as the ones shown in Figs. 1 and 5 should be such that a uniform glow or region of ionization fills the greater part of the envelope. In general, this pressure will be less than the pressure in tubes such as 53 and 143, shown in Figs. 2 and 6, respectively, where the flow is to be confined to the region of an electrode.

It will be apparent that various other modifications may be made in my invention without departing from the spirit and scope thereof, and I desire, therefore, that only such limitations shall be placed thereon as are necessitated by the prior art and are imposed by the appended claims.

I claim:

1. In combination, means for radiating a beam of radio frequency energy, means for producing a plane of ionized gas, means for mounting said plane of ionized gas in said beam at an angle to the axis of said beam for preventing that portion of said beam which is reflected by said gas from returning to said radiating means, and means for varying the ionization of said gas in accordance with a signal.

2. In combination, means for radiating a beam of polarized radio frequency energy, means for producing a plane of ionized gas approximately normal to the axis of said beam, said means including a gas-filled envelope having an electrode therein comprising a plurality of parallel conductors, said conductors being normal to the plane of polarization of said beam, and means for varying the ionization of said gas in accordance with a signal, whereby said signal is applied to said beam.

3. In combination, means for radiating a beam of radio frequency energy, means for producing a plane of ionized gas, means for mounting said plane of ionized gas in said beam at an angle to the axis of said beam for minimizing the return of said beam to said radiating means after reflection from said gas, and means for varying the ionization of said gas in accordance with a signal whereby said signal is applied to said beam.

4. In combination, means for radiating a beam of radio frequency energy, means for producing a plane of ionized gas, means for mounting said plane of ionized gas in said beam at an angle to the axis thereof to avoid reflecting said beam back to said beam producing means, and means including said ionized gas for modulating said beam.

5. In combination, means for radiating a beam of radio frequency energy, means for producing a plane of ionized gas, said means comprising a tube bent back and forth upon itself to form a grid-like structure and containing said gas, means for mounting said plane of ionized gas in said beam at an angle to the axis thereof to avoid reflecting said beam back to said beam radiating means, and means for varying the ionization of said gas in accordance with a signal to thereby modulate said beam.

6. In a radio system, means for generating electric energy of a high radio frequency, means for radiating said energy in a plane of polarization, means including a plurality of parallel conductors for producing a plane of free electric charges, means for mounting said parallel conductors in the field of said energy so that said parallel conductors are perpenicular to said plane of polarization to thereby minimize reflections, and means for varying the number of said free electric charges in said plane in accordance with a signal.

7. The method of modulating a beam of radio frequency energy by means of a plane of ionizable gas which comprises generating and transmitting a beam of radio energy through said ionizable gas, substantially eliminating reflections of said energy from said plane of ionizable gas toward the source of said beam, and varying the ionization of said gas in accordance with a signal.

8. The method of signaling which comprises generating and transmitting radio frequency energy in the form of a beam, creating a region containing free electric charges substantially in a plane, said charges being in the path of said beam, adjusting said plane to substantially reduce reflection of said energy from said plane toward the source of said beam, and varying the number of said free electric charges in said region in accordance with a signal.

ERNEST G. LINDER.