

Jan. 18, 1938.

E. G. LINDER

2,106,149

RADIO APPARATUS

Original Filed Aug. 31, 1933

Fig. 1

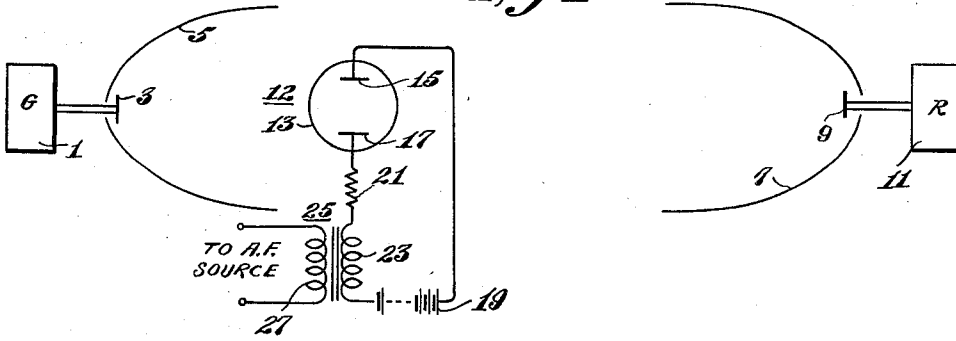


Fig. 4

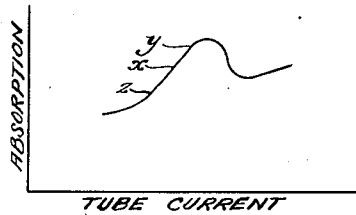


Fig. 2

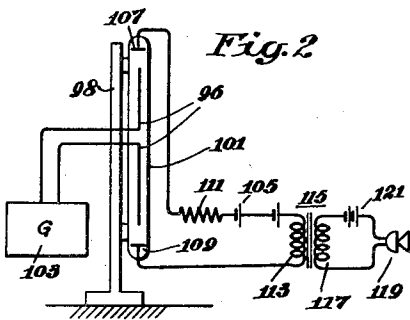
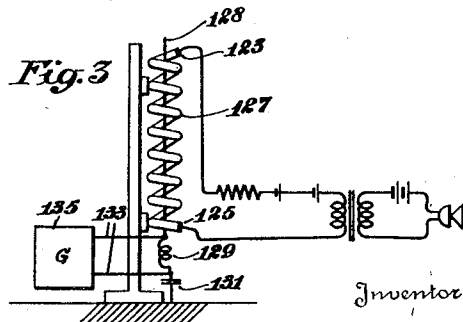


Fig. 3



Inventor

Ernest G. Linder

*J. J. Juff*

Attorney

# UNITED STATES PATENT OFFICE

2,106,149

## 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. 84,264

9 Claims. (Cl. 179—171)

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

This application is a division of my co-pending application Serial 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 a co-pending application of Irving Wolff, Ser. No. 687,599 filed August 31, 1933, Patent No. 2,078,302, April 27, 1937, 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.

In practicing my invention, I improve upon the system disclosed in the above-mentioned Wolff application by interposing a region of free electric charges in the path of a radio wave 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 drawing in which

Figure 1 is a schematic diagram of embodi-

ments of my invention utilizing a beam of radio energy;

Fig. 2 is a schematic diagram of another embodiment of my invention in which the radio energy is broadcast instead of being concentrated into a beam;

Fig. 3 is a schematic diagram of a modified form of the invention as illustrated in Fig. 2;

Fig. 4 is a curve showing the selective absorption characteristic of the gases preferably utilized in certain of said modulation devices.

The embodiment of the invention 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 embodiment of my 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 indicated on the drawing as being an audio frequency source.

By means of this circuit, the gas in the envelope 13 is maintained constantly ionized by the direct current potential of source 19, while the degree of ionization is varied in accordance with the modulating voltage appearing across the secondary 23. I have found that such a device will produce an undistorted modulated radio beam at the

receiver. For example, if voice currents are put through the primary 27, the voice can be heard at the receiver in its original undistorted form.

5 The modulating device 42 may be positioned to intercept the radio beam at any point, although obviously the preferred position is relatively close to the transmitter reflector 5. If desired, the envelope may be placed inside the transmitter reflector, itself.

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

The above described apparatus provides substantially pure amplitude modulation. The stability 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.

A further advantage inherent in this type of system is that a radio beam of greater intensity can be obtained from a given oscillator, since the oscillator may be adjusted for maximum output without regard to where the operating point lies on the characteristic curve of the oscillator. That is, the oscillator and modulator adjustments are independent of each other.

My invention is not restricted to beam transmission systems, but may be applied to transmitting systems in which the radio energy is radiated in all directions. For example, as illustrated in Fig. 2, a dipole antenna 96 mounted upon a non-conducting mast 98 may be surrounded completely by ionized gas enclosed in a long glass tube 101. In this arrangement, the high frequency generator 103 connected to the antenna may, for example, generate energy having a wave length of the order of two or three meters.

The modulating circuit comprises a source of direct current potential 105 connected to electrodes 107 and 109 positioned at the ends of the tube 101 to provide a modulating device. The electrode circuit includes a resistor 111 and the secondary 113 of an audio frequency transformer 115. The primary 117 of the transformer is connected to a microphone 119 through a potential source or battery 121.

60 Instead of a dipole antenna, one of the type illustrated in Fig. 3 may be enclosed by the envelope 101. In Fig. 3, however, the antenna is not located in the ionized gas, so that it is in contact with the gas, but is surrounded by a helical tube of ionized gas which may be wound as shown, or otherwise disposed around the antenna. In this arrangement, electrodes indicated at 123 and 125 at the ends of the gas filled tube 127 are connected to a modulating circuit, which is the same as the one shown in Fig. 2.

70 Radio energy may be supplied to the antenna 128 by means of any of the well known coupling circuits. In the circuit illustrated, the lower end of the antenna 128 is connected to the upper end of an inductance coil 129 which has its lower end connected to one terminal of a condenser 131, the other terminal of condenser 131 being connected to ground. A trans-

mission line 133 is provided to couple the generator 135 to the inductance coil 129.

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 invention. 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.

15 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, 2 and 3 should be such that a uniform glow or region of ionization fills the greater part of the envelope.

Since some ionized gases show selective absorption for certain wave lengths due to plasma oscillations of electrons or ions, greater efficiency of modulation and demodulation may be obtained by operating near or at such absorption band. Fig. 4 shows how one of my modulating devices operating in the neighborhood of an absorption band (the device shown in Fig. 1, for example), will absorb the radio beam as the current through the modulating device is changed.

It is well known that certain gases exhibit a resonant effect which causes them to absorb a comparatively large amount of energy having a wave length corresponding to the resonant point of the gas. Assume that a radio beam of a certain wave length is impressed upon one of my gas modulating devices as shown in Fig. 1, Fig. 2, or Fig. 3, for example. If the gas pressure is made the proper value, the current through the modulating device can be increased until the gas absorbs the beam the maximum amount, that is, a resonant peak is obtained.

This resonant effect may be utilized in modulating the beam by adjusting the current through the modulating device until the point  $x$  on the curve is reached. The modulation then varies the modulating tube current about the point  $x$  so that the absorption of the radio beam is varied between the limits  $y$  and  $z$ .

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 as my invention:

1. In combination, means including an antenna for radiating radio energy, means for surrounding said antenna with ionized gas, and means for varying the ionization of said gas in accordance with a signal.

2. In combination, means including an antenna for radiating radio energy, means for surrounding said antenna with a region containing free electric charges, and means for varying the number of said free electric charges in accordance with a signal.

3. In combination, means including an an-

tenna for radiating radio energy, means for immersing said antenna in an ionized gas, and means for varying the ionization of said gas in accordance with a signal.

5 4. In combination, means including an antenna for radiating radio energy, means for immersing said antenna in a region containing free electric charges, and means for varying the number of said free electric charges in accordance with a signal.

10 5. The method of signaling which comprises generating and radiating electromagnetic radio frequency energy in all directions, creating a region containing free electric charges, passing said radiated energy through said region, and varying the number of said charges in accordance with a signal.

15 6. The method of signaling which comprises generating and radiating electromagnetic radio frequency energy in all directions, creating a region of ionized gas, passing said radiated energy through said region, and varying the degree of ionization in accordance with a signal.

20 7. The method of signaling which comprises

generating and radiating electromagnetic radio frequency energy in all directions, creating a region of ionized gas, passing said radiated energy through said region, varying the degree of ionization in accordance with a signal, and absorbing 5 energy from said broadcasted energy.

8. Electrical apparatus comprising means for generating electromagnetic energy at a high radio frequency, means for radiating said energy in substantially all directions, means for intercepting said energy by an ionized gas, said gas being confined in an envelope which substantially surrounds said radiating means, and means for controlling the electromagnetic energy absorbing properties of said ionized gas in accordance with a signal.

9. In combination, means including an antenna for broadcasting radio frequency energy, a spirally wound tubular envelope surrounding said antenna, an ionized gas retained within said 20 envelope, and means for varying the ionization of said gas in accordance with a signal.

ERNEST G. LINDER.