July 14, 1936. E. G. LINDER 2,047,929

IONIC MODULATOR

Filed Feb. 28, 1935

Fig. 1.

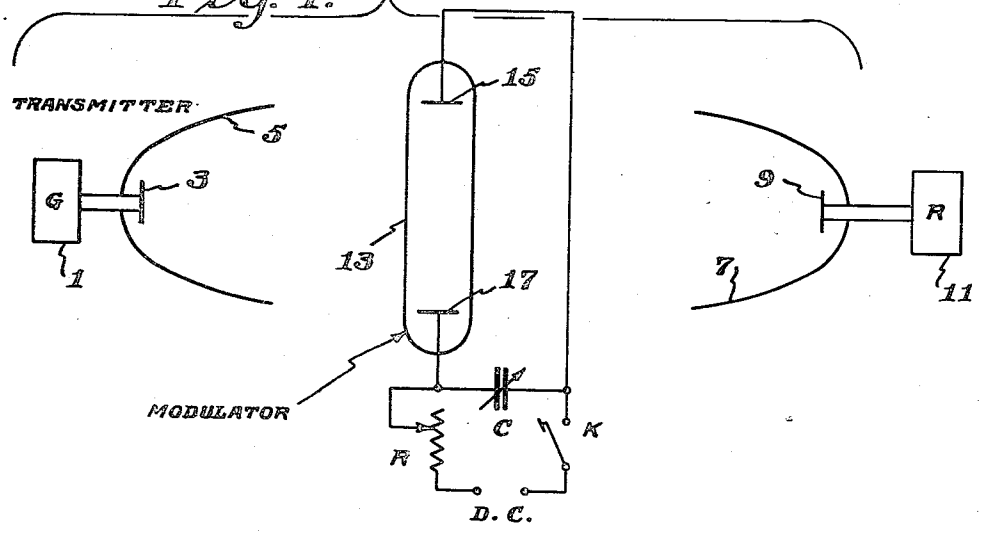


Fig. 2.

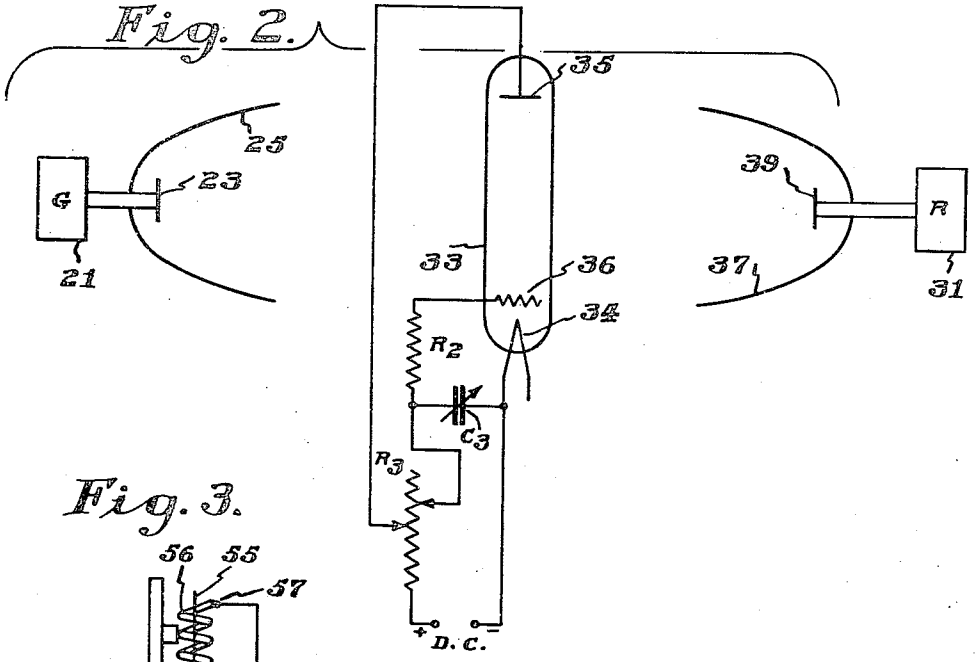
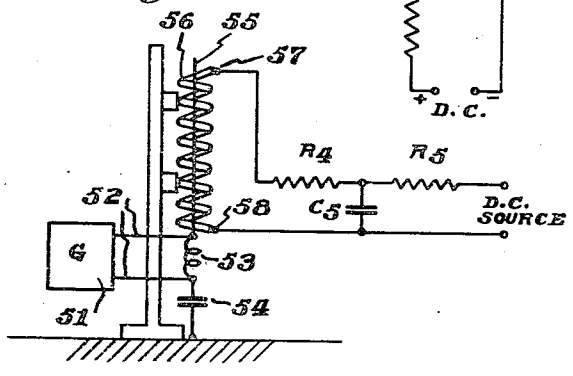


Fig. 3.



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IONIC MODULATOR

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Application February 28, 1935, Serial No. 8,645

9 Claims. (Cl. 179—171)

This invention relates to systems for modulating radio energy having a short wave length, particularly to systems of the type disclosed in copending applications, Serial No. 687,544 to Ernest G. Linder and Serial No. 687,599 to Irving Wolff, both filed August 31, 1933 and assigned to the same assignee as this invention.

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

The above identified inventions are predicated upon the discovery that the difficulty in modulating such energy at the generator itself (as taught by prior art) 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. The invention resides further in positive control of carrier waves subsequent to radiation by means of a modulating tube having a useful gas content.

The principal object of the present invention is to provide an "automatic" modulator of this general type.

Another object is to provide a non-mechanical chopper adapted for use in carrier telegraph systems whereby a signal after being intercepted and made audible in the distant receiving set, produces a signal having characteristic tone.

Still another object of the invention is to provide a novel and useful radio beacon adapted to transmit recurring short wave signals of constant and definite frequency.

The novel features characteristic of the invention are set forth with particularity in the appended claims. The invention itself, however, both as to structure and method of operation, will be best understood by reference to the following description taken in connection with the accompanying drawing wherein

Figure 1 is a schematic diagram of an automatic ionic, beam-modulating system within the invention employing a two-element cold-cathode discharge tube;

Fig. 2 is a similar diagram of a beam-modulating system employing a grid controlled thermionic gas tube; and

Fig. 3 is a schematic diagram of another embodiment of the invention in which the radio energy is broadcast instead of being concentrated into a beam.

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 at the generator itself, in which case the modulated radio energy is impressed upon the transmitting antenna. As previously indicated, 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 invention disclosed in Serial No. 687,544, above identified, the radio beam is passed through an ionic modulator which is positioned directly in the path of the radio beam. The gas is maintained in an ionized condition and the density and/or distribution of the glow discharge 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. are varied by the modulating voltage which is preferably impressed upon the tube circuit by means of a suitable transformer in electrical association therewith.

In carrying the present invention into effect, I provide a gas discharge tube which may be similar in construction to that of the earlier application comprising an envelope 13 filled with an ionizable gas and a pair of oppositely located ionizing electrodes 15 and 17. As indicated in the drawing, the gas is rendered conductive by reason of the potential drop between these spaced "cold" electrodes which are connected to a direct current source D. C. of suitable potential. Instead of maintaining the gas ionized at all times I provide automatic means for interrupting the conductivity of the device at a desired rate. As previously set forth, these interruptions serve, when the circuit forms part of a carrier telegraph system, to impart a characteristic tone to the signal.

Resistor R shown in series with electrodes 15 and 17 and energizing source D. C. fulfills two functions, it serves to limit the current through the tube, and together with condenser C, in shunt therewith, determines the frequency at which the glow discharge is periodically created and extinguished. With the arrangement shown, this frequency may be fixed in accordance with the formula:

$$f=\left(RC \log \frac{V-Vo}{V-V1}\right)^{-1}$$

where V is the applied potential, Vo is the breakdown potential, V1 is the extinction potential.

Any suitable keying system capable of making and breaking a circuit employing voltages of the order dictated by the particular ionizing potential of the gas, may be used.

The grid controlled ionic modulator of Fig. 2 comprises a gas receptacle **33**, an anode or plate **35**, a control grid **36** and a thermionic cathode **34**. Cathode **34** which may be of any desired configuration and energized by a suitable source of heating current, not shown, is provided to maintain the gas in a pre-glow condition. Anode **35** is adjustably connected to the positive terminal of the direct current source through a balancing resistor R3, grid **36** is similarly connected to source D. C., through resistor R2 but at a lower potential point. The discharge interrupting circuit R2—C3 is in series with the filament **34** and grid **36**.

The drawing of Fig. 2 omits the key of Fig. 1 and it may be understood that either circuit with the key omitted may be used to transmit recurring short wave signals of definite period and at a constant frequency. Impulses of the type described may be employed for instance in radio beacons.

The other elements of the system are similar to that of Fig. 1, thus the generator is **21**, the transmitting antenna **23** and the parabolic reflector **25**. The receiver is designated **31**, the receiving antenna **39** and the reflector **37**.

The automatic ionic modulator of the present invention is useful in transmitting systems of the broadcast type as well as in transmitters of the beam or directional type.

Fig. 3 shows the invention adapted for use in a broadcasting system of the type shown in my earlier disclosure. Radio energy from generator **51** may be supplied to the antenna **55** by means of any of the well known coupling circuits. In the circuit illustrated, the lower end of the antenna **55** is connected to the upper end of an inductance coil **53** which has its lower end connected to one terminal of condenser **54**, the other terminal of condenser **54** being connected to ground. A transmission line **52** is provided to couple the generator **51** to the inductance coil **53**. The ionized gas modulating device illustrated is in the form of a spiral tube **56** surrounding the antenna **55**. Tube **56** may, however, be of any other convenient structure. The ionizing electrodes **57** and **58** are positioned at opposite ends of the tube and are connected to energizing source D. C. through a balancing resistor R4. As in Fig. 1 the automatic modulating circuit comprises a series resistor R5 and a shunt capacitance C5. A suitable keying system, not shown, may be provided if desired.

As a number of possible embodiments may be made of the above invention, and as changes may be made in the embodiments set forth without departing from the spirit and scope of the invention, it is to be understood that the foregoing is to be interpreted as illustrative and not in a limiting sense, except as required by the appended claims and by the prior art.

I claim as my invention:

1. Method of signaling which comprises generating energy of radio frequency, transmitting said energy and modulating said energy by periodically creating in accordance with desired signals an ionized discharge in the path of said transmitted energy.

2. Method of signaling which comprises generating energy of radio frequency, transmitting said energy, and modulating said energy by creating in accordance with desired signals an ionized discharge in the path of said transmitted energy and periodically extinguishing said ionized discharge at an audio frequency.

3. Method of code signaling which comprises generating energy of radio frequency, transmitting said energy, and modulating said energy by creating an ionized discharge in the path of said transmitted energy, periodically interrupting said ionized discharge at an audible rate and keying said interrupted discharge in accordance with the code.

4. The combination in a radio system having means for transmitting high radio frequency energy of an ionic gaseous discharge device positioned in the path of said energy for modulating said energy in accordance with the frequency of desired signal representing currents, and means for applying said signal representing currents to said discharge device and varying said discharge in accordance with said currents.

5. In a radio system, means for radiating high radio frequency energy, means for modulating said energy comprising a gas filled receptacle positioned in the path of said energy and means for periodically creating in accordance with desired signals a glow discharge in said receptacle.

6. In a radio system, means for radiating high radio frequency energy, means for modulating said energy comprising a gas filled receptacle positioned in the path of said energy, means for creating in accordance with desired signals a glow discharge in said gas and means for periodically extinguishing said discharge at an audio frequency.

7. In a radio system, means for radiating high frequency energy, means for modulating said high frequency energy comprising a gas filled receptacle positioned in the path of said energy, a pair of electrodes in said receptacle, a circuit including a source of potential connected to said electrodes for creating a glow discharge in said gas, means for automatically interrupting said glow discharge at a definite frequency, and means in said circuit for keying said interrupted discharge.

8. A system for modulating transmitted radio frequency energy of constant amplitude and definite frequency comprising a receptacle having an ionizable gas content positioned in the path of said transmitted energy, a pair of electrodes in said receptacle, a circuit including a source of potential in series with said electrode for creating a glow discharge in said gas and means including a series resistance and a shunt capacitance in said circuit for alternately ionizing and extinguishing said glow discharge at a desired frequency.

9. A system in accordance with claim 8 and wherein the frequency at which said gas is alternately ionized and extinguished is determined by the formula:

$$f=\left(RC\log\frac{V-Vo}{V-VI}\right)^{-1}$$

where R is the value of the series resistance, C is the value of the shunt capacitance, V is the applied potential, Vo is the breakdown potential of the gas, V1 is the extinction potential of the gas.

ERNEST G. LINDER.