May 23, 1939. V. K. ZWORYKIN 2,159,937

ELECTRICAL DEVICE

Original Filed Aug. 31, 1933

FIG. 1.

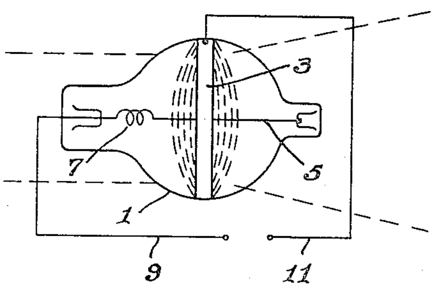


FIG. 5

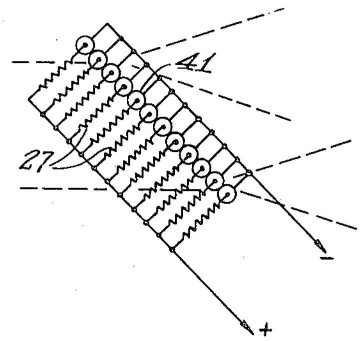


FIG. 2.

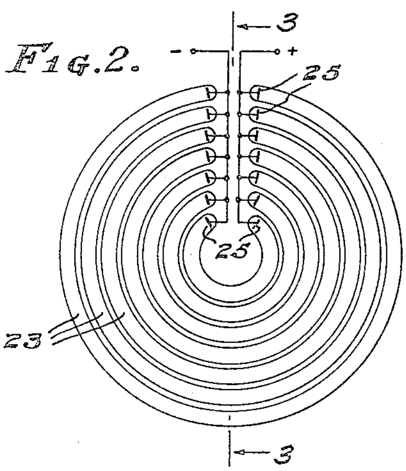


FIG. 3.

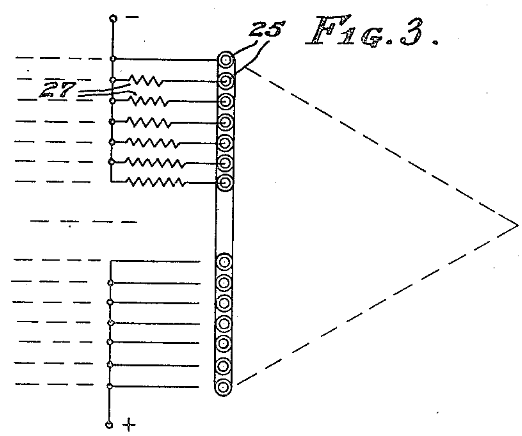


FIG. 4.

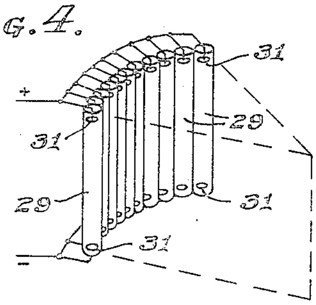
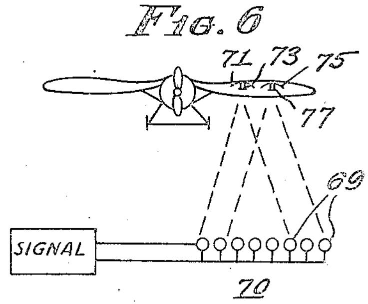


FIG. 6



Inventor

Vladimir K. Zworykin

By

Attorney

Patented May 23, 1939 **2,159,937**

UNITED STATES PATENT OFFICE

2,159,937

ELECTRICAL DEVICE

Vladimir K. Zworykin, Philadelphia, Pa., assignor to Radio Corporation of America, a corporation of Delaware

Original application August 31, 1933, Serial No. 687,575, now Patent No. 2,085,406, dated June 29, 1937. Divided and this application May 21, 1936, Serial No. 81,004

7 Claims. (Cl. 250—1)

My invention relates to radio devices and particularly to such devices as lenses and the like for focusing, reflecting, or otherwise acting upon radio energy, and is a division of my copending application Serial No. 687,575, filed August 31, 1933, Patent No. 2,085,406 dated June 29, 1937, and entitled Electrical devices.

It is well known that radio energy having a short wave length (of the order of 10 centimeters, for example) can be focused, reflected, dispersed, etc. much the same as light by utilizing lenses, prisms, or the like, made of a proper material such as paraffin.

An object of my invention is to provide devices of the above mentioned type which will be efficient in operation and comparatively cheap to manufacture.

A further object of my invention is to provide devices of the above mentioned type having quasi-optical properties which can be controlled in accordance with a voltage.

More specifically, an object of my invention is to provide ionized gas or space-charge devices for causing radio energy to be refracted, dispersed, reflected, and the like.

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

Figure 1 is a side view of a lens constructed in accordance with my invention and designed to diverge a radio beam;

Fig. 2 is a view of a modified form of a lens embodying my invention;

Fig. 3 is a view taken on the line of 3—3 looking in the direction of the arrows;

Fig. 4 is a view of one embodiment of my invention designed for reflecting a radio beam;

Fig. 5 is a view of a refracting device utilizing the elements shown in Fig. 4;

Fig. 6 is a view illustrating one of the uses for my improved devices.

The embodiment of my invention illustrated in Fig. 1 comprises an envelope **1** which is approximately spherical in form and which is filled with a gas which can be readily ionized. One electrode of the device consists of a metal band **3** in the form of a circle painted or deposited in any suitable manner upon the inside of the glass envelope **1**.

The other electrode consists of a wire **5** extending at right angles to the plane of the ring electrode **3** and through the middle of the ring. The electrode **5** is held taut by means of a spring **7**. Either a steady or a varying potential may be impressed upon the electrodes **3** and **5** through the conductors **9** and **11**, depending upon whether a fixed or varying lens action is desired.

By using a suitable gas at the proper pressure, a region of gas inside the envelope **1** will be ionized, this region having the shape indicated by the dotted lines. By preference the pressure should be such that the ionized glow will be of the uniform type found in that region called the positive column. This characteristic discharge is well known to those skilled in the art; it is found at gas pressures varying from several tenths of a millimeter to several centimeters of mercury. It will be evident that these dotted lines indicate the distribution of the electric field inside the container, and, since it is the region within this electric field which is ionized, the dotted lines also indicate the portion of the gas which is ionized. The electrodes are shaped and positioned to produce an electrostatic field of shape corresponding to the required lens action.

It will be seen that this portion of ionized gas is in the shape of a disc which is thick in the middle and thin at the edge. Since ionized gas has an index of refraction which is less than unity for the radio waves, such waves will travel through the center of this gas lens more rapidly than through air, and the radio beam will be diverged by the lens.

Various gases or gas mixtures may be used in my lens but in general, one of the noble gases, such as neon, or a mixture of such gases, will be preferred.

The gas pressure may vary within wide limits, but preferably it should be low enough so that the ionized region of the gas will be uniformly ionized. Under this condition, it will be apparent that the lens properties of the device shown in Fig. 1 will depend mainly upon the shape of the ionized gas region.

From the foregoing description it will be understood that the lens properties of the device shown in Fig. 1 are substantially independent of the shape of the envelope **1**, the effective lens shape being determined by the distribution of the electric field.

Fig. 2 shows a form of lens utilizing a plurality of circular gas-filled tubes **23**. Each tube has two electrodes **25** therein, one at each end of the tube, for impressing an ionizing potential upon the gas. This form of lens may be made either converging or diverging by changing the intensity of the discharge in each tube **23**.

If a diverging lens is desired, the intensity of the discharge in the outer tube will be made greater than that in any of the other tubes. The intensity of discharge will be graduated from a heavy discharge in the outer tube, through a diminishing discharge in the intermediate tubes, to a small discharge in the center tube. If a converging lens is desired, the discharge in the center tube will be made the heaviest, and the discharge in the outer tube the smallest.

Fig. 3 indicates how the degree of discharge or ionization in the different tubes 23 may be adjusted. All the tubes may be connected in parallel, as shown, each tube having a different value of resistance in series with it. Thus, as shown in Fig. 3, the outer tube is connected directly across a voltage source, and the next tubes have resistance units 27 of increasing value in series with them, the center tube having the largest value of resistance in series with it so that the ionization discharge in this tube will be small.

Fig. 4 illustrates a cylindrical mirror comprising a plurality of gas-filled tubes 29, each tube having an electrode 31 at each end. When the gas in tubes 29 is ionized, they will act as a mirror to reflect any radio energy striking them. They may be designed to focus the parallel rays of a radio beam, as indicated in the figure.

Fig. 5 illustrates a prism made up of elements 41 constructed the same as the tubes shown in Fig. 4. Each tube 41 has an intensity of discharge which is different than that of the other tubes, and by means of a plurality of resistors 27 these intensities of discharge are graduated in the manner described in connection with Figs. 2 and 3.

Fig. 6 illustrates a signaling device 70 for airplanes or the like. A group of gas-filled tubes 69 such as shown in Fig. 5 are connected in parallel and supplied with an ionizing voltage modulated by an identifying signal. This group of tubes is located on or near the earth at a point where an airplane pilot may wish to determine his position. For example, the device may be placed at one corner of a landing field.

The airplane will carry means for transmitting and receiving a radio beam. In Fig. 6 there is shown a transmitting reflector 71 with its dipole antenna 73 and a receiving reflector 75 with a receiving dipole antenna 77. To locate the corner of the landing field, a radio beam will be transmitted from reflector 71. This beam will be reflected from the ground and received by reflector 75. If the airplane passes over the device 70, the reflected beam will be modulated by the identifying signal and the pilot will then know his exact position.

The same apparatus may be employed for locating and identifying ships in the dark or in a fog. The modulating device 70 will be placed on a side of a ship and on the outside so that a radio beam reflected from the side of the ship will pass through device 70 and be modulated by a signal identifying the ship.

It will be understood that a portion of the radio beam will be reflected from the modulating device itself instead of from the earth. This portion of the beam also will be modulated since both the absorbing ability and the reflecting ability of the tubes will vary with the degree of ionization.

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 set forth in the appended claims.

I claim as my invention:

1. An electrical mirror for ultra high radio frequency energy comprising a plurality of straight gas-filled tubes arranged in juxtaposed relation with their longitudinal axes parallel so as to form a semi-cylindrical surface, means for ionizing said gas, a beam of ultra high radio frequency energy, and means for impressing said beam on said tubes whereby parallel rays of said ultra high frequency radio energy striking said surface will be brought into a desired focus.

2. In an electrical device, means for reflecting or refracting ultra high radio frequency energy, said means comprising a plurality of straight gas-filled tubes placed in juxtaposed relation with their longitudinal axes parallel to each other, each of said tubes having a pair of electrodes, means connecting respective electrodes in parallel, means for ionizing said gas, a source of ultra high radio frequency energy, and means for impressing at least a portion of said energy on said tubes whereby said energy is reflected or refracted a desired amount.

3. An electrical reflector for ultra high radio frequency energy comprising a plurality of straight gas-filled tubes arranged in juxtaposed relation with their longitudinal axes parallel so as to form a semi-cylindrical surface, each of said tubes having a pair of electrodes, means connecting respective electrodes in parallel, means for ionizing said gas, a source of ultra high radio frequency energy, and means for impressing at least a portion of said energy on said surface, whereby the rays of said energy will be brought to a desired focus.

4. In a device for changing the course of a beam of ultra high radio frequency energy, a plurality of straight tubes filled with gas and placed in juxtaposed position with their longitudinal axes parallel, means for ionizing said gas, and a beam of ultra high radio frequency energy, said tubes being so positioned and arranged in said beam that the course of said beam is changed a desired amount.

5. A device for altering a beam of ultra high radio frequency energy comprising a plurality of straight gas-filled tubes placed in juxtaposed relation with their longitudinal axes parallel to each other, said tubes being in the same plane, means for producing discharges of different relative intensities in said tubes, a beam of ultra high radio frequency energy, and means for impressing said beam on said tubes whereby said beam is altered a desired amount by said device.

6. A device for altering a beam of ultra high radio frequency radio energy comprising a plurality of straight gas-filled tubes placed in juxtaposed relation with their longitudinal axes in a plane, means for producing discharges of different relative intensities in said tubes, said intensity of discharge being graduated from a middle tube to an outer tube, a beam of ultra high radio frequency energy, and means for impressing said beam on said tubes so as to alter said beam a desired amount.

7. In combination, means for radiating a beam of ultra high radio frequency energy, means for reflecting at least a portion of said beam, a plurality of gas-filled tubes containing free electric charges positioned between said radiating means and said reflecting means, means for controlling said electric charges in accordance with an identifying signal to thereby modulate said reflected portion of said beam, and means for receiving said reflected and modulated portion of said beam.

VLADIMIR K. ZWORYKIN.