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ELECTROMAGNETIC HORN

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Fig. 1.

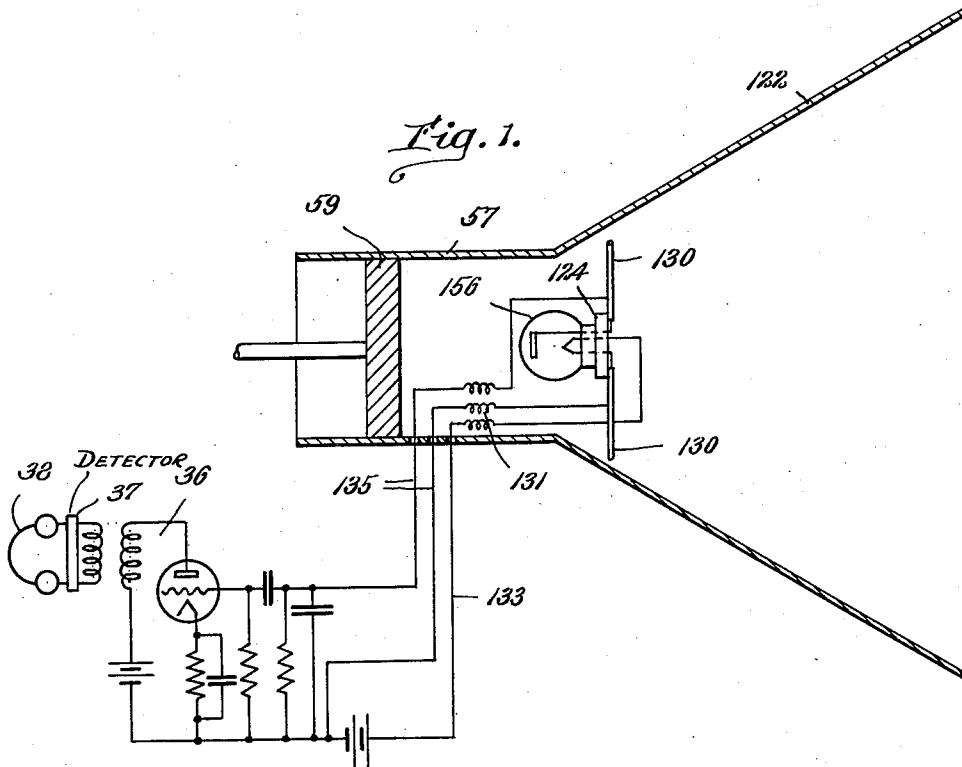
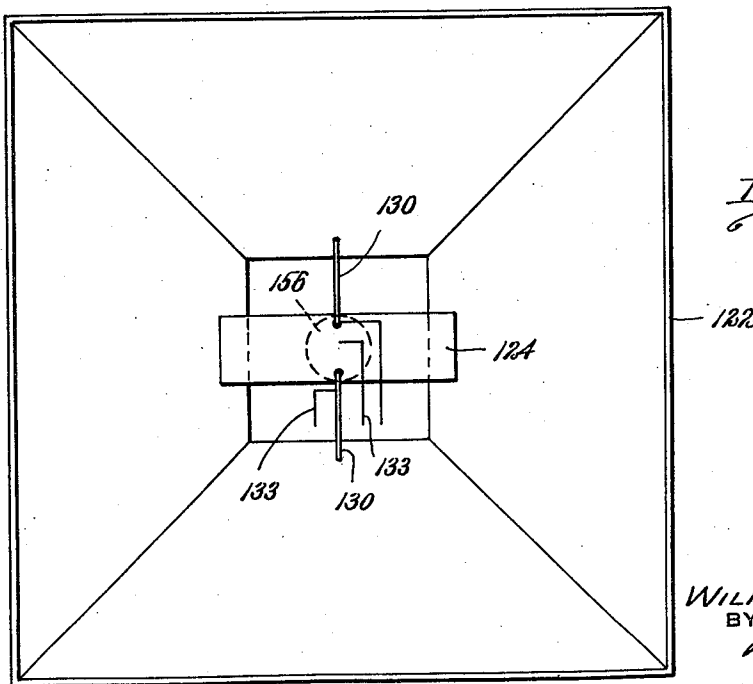


Fig. 2.



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ELECTROMAGNETIC HORN

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Application November 15, 1938, Serial No. 240,545

5 Claims. (Cl. 250—11)

The present invention relates to electromagnetic horns. The present application is a continuation-in-part of application, Serial No. 227,183, filed August 27, 1938.

According to the invention disclosed in the said application, an antenna or other translating apparatus is positioned directly in the throat or small end of the horn, outwardly of any portion thereof that may be of substantially uniform cross section. When used as a transmitter, the horn operates to excite directly waves of horn type or horn waves, with the result that a beam is radiated from the mouth or large end of the horn of character appropriate to the horn itself, rather than to the antenna and other apparatus. The horn operates with equal efficiency as a receiver.

An object of the present invention is to improve upon horns of the above-described character, to the end of preventing the passage of radio-frequency energy outside of the horn except at the mouth or large end of the horn.

Other and further objects will be described hereinafter and will be particularly pointed out in the appended claims.

The invention will now be described in connection with the accompanying drawing, in which Fig. 1 is a diagrammatic view of circuits and apparatus embodying the present invention, showing, in longitudinal section, an electromagnetic horn with vacuum-tube apparatus disposed directly in the throat of the horn and embodying also an adjustable plunger; and Fig. 2 is a front view of the apparatus shown in Fig. 1.

Vacuum-tube or other energy-translating apparatus 156, together with a projecting exciting or absorbing antenna rod or rods 130 connected thereto, may be mounted approximately centrally, directly in the throat or small or reflecting end of an electromagnetic horn 122, outwardly of any portion thereof at the small end of the horn, such as an elongated tubular or pipe body portion or section 57, that may be substantially uniform in cross section. No wave guide or chamber, resonant or otherwise, need be provided for generating the waves or receiving them. The translating apparatus is shown supported upon a dielectric or insulating support 124, shown as fixed to opposite sides of the horn, centrally of its throat. The rods 130 are shown disposed substantially at right angles to the axis of the horn 122. The antenna rods 130 are so constructed and positioned that electromagnetic waves produced thereby in the small end of the horn shall be transversely polarized; that is, the electric

intensity will be entirely in surfaces normal to the direction of propagation. In certain modifications, the exciting or absorbing rods 130 may be disposed unsymmetrically in the horn, to give a modified directive pattern for the radiant energy. In sending or radiating, electromagnetic-wave energy produced by the exciting rods 130, near the small end of the horn, will be propagated through the interior of the horn to the mouth as "horn waves." At the mouth, substantially all of this energy is radiated out into free space as ordinary radio waves. The horn 122 thus constitutes a directive electromagnetic radiator.

In receiving, a similar, but reverse, process takes place, the electromagnetic waves being received by the horn, and communicated to a receiving system, and the signal comprising the intelligence will be recovered by demodulation. The modulated ultra-high-frequency energy may be taken from the conductors and delivered to the horn 122, or it may be received by the horn and delivered to the conductors.

The horn 122 is illustrated as constituting a flared-out continuation, at the free open end, of the elongated tubular or pipe body portion or section 57. The portion 57 may extend over any desired distance from the horn, to the left, as viewed in Fig. 1. The pipe portion 57 may constitute a shield for wires or leads 133, 135 and other apparatus contained therein. The leads 133, 135, which extend through openings in the wall of the horn to connect the vacuum tube 156 and radio-frequency choke coils 131 to apparatus outside the horn, may be spaced from the walls of the tube 57 by insulating members (not shown). The principal axis of the horn extends between the smaller and the larger ends of the horn.

The horn may be constituted of a formed sheet of conducting material, like metal, such as copper or aluminum, or it may be constituted of other material if its inner wall is otherwise rendered a conductor of the said waves. The space inside the horn, being open to the atmosphere, is naturally a non-conductor.

If the horn 122 is of simple rectangular shape, the pipe portion 57, from which it flares out, may be likewise rectangular. For beam transmission, a horn of rectangular cross section, with an orientation of the exciting rod perpendicular to the horn axis, offers certain features, among them the important feature of a radiated space wave polarized with the electric vector mainly in a single direction. The rectangular cross section

may be such that the sides of the horn shall flare in four oppositely disposed directions, or two of the sides may be substantially parallel. Other shapes also may be employed, either for receiving or sending.

The vacuum-tube apparatus 156 may be of any desired type, depending upon the use to which it may be put; it is shown as a high-vacuum diode rectifier or detector, but it may, for example, be a Barkhausen tube, a triode, or a magnetron. Any of these, and also a crystal detector, may be connected in series with the rods 130, with or without a by-pass condenser, as hereinafter explained. It may also be of the Peterson type described in the General Radio Experimenter for October, 1937.

The device may be used for sending or receiving, depending upon whether sending or receiving apparatus is connected to leads 133 and 135. The exciting or absorbing rod or rods 130 may be connected to terminal apparatus at the smaller end of the horn, which terminal apparatus may be connected either to sending or to receiving apparatus at a sending or receiving station, to radiate modulated high-frequency electromagnetic waves from the horn or to conduct down the hollow tube waves received by the horn.

The modulated electromagnetic energy received by the antenna 130 of the horn 122 will, after demodulation, be amplified by an amplifier 36, and the amplified energy will be detected by a detector 37 coupled to the amplifier and evidenced in a loud-speaker or telephones 38 connected to the detector. The direct or other demodulated current may be led out of the horn through radio-frequency choke coils 131 to the amplifier and the ear phones. The choke coils 131 prevent the passage of radio-frequency energy outside of the horn except at the mouth of the horn.

The lead 133 extends to the filamentary cathode and the leads 135 to the anode or plate of the diode 156. Power supply and modulating current leads are carried into the detector 156, preferably through a shield, and preferably at right angles to the antenna. A conducting barrier 59 may be disposed in the body portion 57, near the small end of the horn. The barrier 59 may be constituted of an adjustable closing reflecting metal or other conducting piston or plunger. The distance between the conducting plunger 59 at the back or throat of the horn and the antenna rod or rods 130 should be adjusted, as by means of a handle, for maximum effect. The purpose of the adjustment may be to resonate or tune the throat of the horn, thereby rendering the throat of the horn more responsive to a particular frequency or a narrow band of frequencies than to other frequencies. Optimum conditions for operation may be provided also in other ways. If the plunger 59 is replaced by a fixed wall, the detector 156 and the antenna rod or rods 130 may be made adjustable by sliding back and forth along the axis of the horn to accomplish the same result. This may be desirable, for example, if the small end of the horn is continued to form an apex (not shown), as illustrated and described in a copending application, Serial No. 230,737, filed September 19, 1938.

If the plunger 59 or other barrier is absorbing or non-reflecting, a response may be obtained over a broader frequency band than is obtainable with a reflecting barrier.

Different types of horn waves, and combinations of the same, may be separately excited and propagated within the horn, or absorbed by

the horn, by properly arranging the exciting rod or rods in the throat of the horn, both as to the position of, and the current in, the rod or rods. One of the most important modes or wave types is the lowest-order transversely polarized horn H or magnetic wave, with the electric vector mainly parallel everywhere to the vertical direction, obtained with an exciting rod transverse to the axis and in the vertical plane. This wave type is probably best for sending a single beam of radiant energy and is the wave most naturally adopted for receiving.

The electromagnetic horn described herein is not to be confused with a reflector. The function of the electromagnetic horn is to guide waves traveling within it and tangentially along its surface in the outward longitudinal direction, smoothly and without interruption, and to direct them along this surface forward out into space. The direction in which it is desired to launch the waves into space is determined by designing the horn so that it shall have a guiding surface or guiding walls in the desired direction connecting the small and the large ends of the horn. A wave reflector, on the other hand, does not guide waves traveling along its surface; there are no waves, indeed, traveling along this surface. The reflector does not and can not mold, form, guide and transmit waves of the character employed in the electromagnetic horn. A wave reflector receives waves traveling at an angle of incidence toward the reflecting surface, abruptly stops them, and then sends them away from the surface out into space at a different angle to the surface, which different angle is known as the angle of reflection. In accordance with geometric-optic principles, the angle of incidence is equal to the angle of reflection.

In the electromagnetic horn, the waves may be regarded as traveling in the dielectric of the space in the horn, continuously outward along the inside conducting horn surface, toward free outer space. The flared horn provides a surface of progressively greater cross-sectional area as the wave travels outward, causing the wave energy to spread over a relatively large area at the mouth for directive transmission, but in such a manner that the wave energy is continuously and smoothly guided and the field configuration of the wave is reasonably maintained during its outward progression. The waves become thus slidably attached to the inside horn surface, and they remain so continuously attached throughout their sliding movement along this inside horn surface, from the small or throat end of the horn until they reach the mouth of the horn. It is in this manner that they become guided by the surface during such travel outward. Upon arrival at the mouth of the horn, the waves become readily disattached from the horn surface, but they continue thereafter to travel into free space, forward in the desired direction of progression of the waves predetermined by the design of the horn. No such action takes place with wave reflectors.

It is, therefore, possible to design horns of a large variety of shapes. The focus-forming surfaces usually found at the small end of parabolic reflectors, furthermore, are not needed according to the present invention. It is desirable to initiate the waves at the small end of the horn in some other manner such as described herein.

The invention is not limited to the exact embodiments thereof that are illustrated and described herein; further modifications may be made by persons skilled in the art without de-

parting from the spirit and scope of the invention, as defined in the appended claims.

What is claimed is:

1. An electric system for radiating electromagnetic waves into or receiving them from free space in a predetermined direction comprising a wave-guide horn having a large end and a small end connected by a wave-guiding surface, translating means for exciting or receiving the electromagnetic waves disposed in the horn at the small end, choke coils for preventing the passage of radio-frequency energy outside the horn except at the large end of the horn, sending or receiving apparatus, and means for connecting the translating means and the choke coils with the sending or receiving apparatus, the guiding surface extending substantially longitudinally of the predetermined direction and being shaped to guide the travel of the excited waves in the horn and tangentially along the surface from the small end toward the large end and forward in the predetermined direction out into free space or to guide the travel of the received waves in the horn and tangentially along the surface from the large end toward the small end.

2. An electric system having, in combination, a pipe one end of which is provided with an electromagnetic wave-guide horn having a small end and joined to the said end of the pipe and a large end, the large end being electromagnetically open to space to permit the horn to receive electromagnetic waves from space or to radiate electromagnetic waves out into space at the large end, an absorbing barrier disposed in the pipe near the said one end, and absorbing or exciting translating means disposed in the horn at the small end outwardly of any portion thereof that may be of substantially uniform cross section near the barrier, the horn having guiding walls between the large end and the small end for guiding the waves received from space at the large end to the translating means at the small end in order that the received waves may be absorbed by the translating means or for guiding to the large end for radiation out into space the waves excited by the translating means at the small end.

3. An electric system having, in combination, an electromagnetic-wave-guide horn having a small end and a large end, the large end being electromagnetically open to space to permit the horn to receive electromagnetic waves from space or to radiate electromagnetic waves out into space at the large end, and absorbing or exciting translating means disposed in the horn at the small end, the translating means comprising a vacuum-tube apparatus and, connected thereto, an antenna and means for preventing the passage of radio-frequency energy outside of the horn except at the large end of the horn, and

the horn having guiding walls between the large end and the small end for guiding the waves received from space at the large end to the translating means at the small end in order that the received waves may be absorbed by the translating means or for guiding to the large end for radiation out into space the waves excited by the translating means at the small end.

4. An electric system having, in combination, an electromagnetic-wave-guide horn having a small end and a large end, the large end being electromagnetically open to space to permit the horn to receive electromagnetic waves from space or to radiate electromagnetic waves out into space at the large end, and absorbing or exciting translating means disposed in the horn at the small end, the translating means comprising vacuum-tube apparatus and, connected thereto, an antenna and means for preventing the passage of radio-frequency energy outside of the horn except at the large end of the horn, the preventing means comprising choke coils, and the horn having guiding walls between the large end and the small end for guiding the waves received from space at the large end to the translating means at the small end in order that the received waves may be absorbed by the translating means or for guiding to the large end for radiation out into space the waves excited by the translating means at the small end.

5. An electric system having, in combination, an electromagnetic-wave-guide horn having a small end and a large end, the large end being electromagnetically open to space to permit the horn to receive electromagnetic waves from space or to radiate electromagnetic waves out into space at the large end, absorbing or exciting means disposed in the horn at the small end, the absorbing or exciting means comprising translating apparatus and, connected thereto, an antenna and means for preventing the passage of radio-frequency energy outside of the horn except at the large end of the horn, and the horn having guiding walls between the large end and the small end for guiding the waves received from space at the large end to the absorbing or exciting means at the small end in order that the received waves may be absorbed by the absorbing means or for guiding to the large end for radiation out into space the waves excited by the exciting means at the small end, and means for connecting the absorbing or exciting means with the means external to the horn for evidencing the received waves absorbed by the absorbing means or with means external to the horn for energizing the exciting means to excite at the small end the waves to be radiated out into space.

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