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DIPOLE ANTENNA

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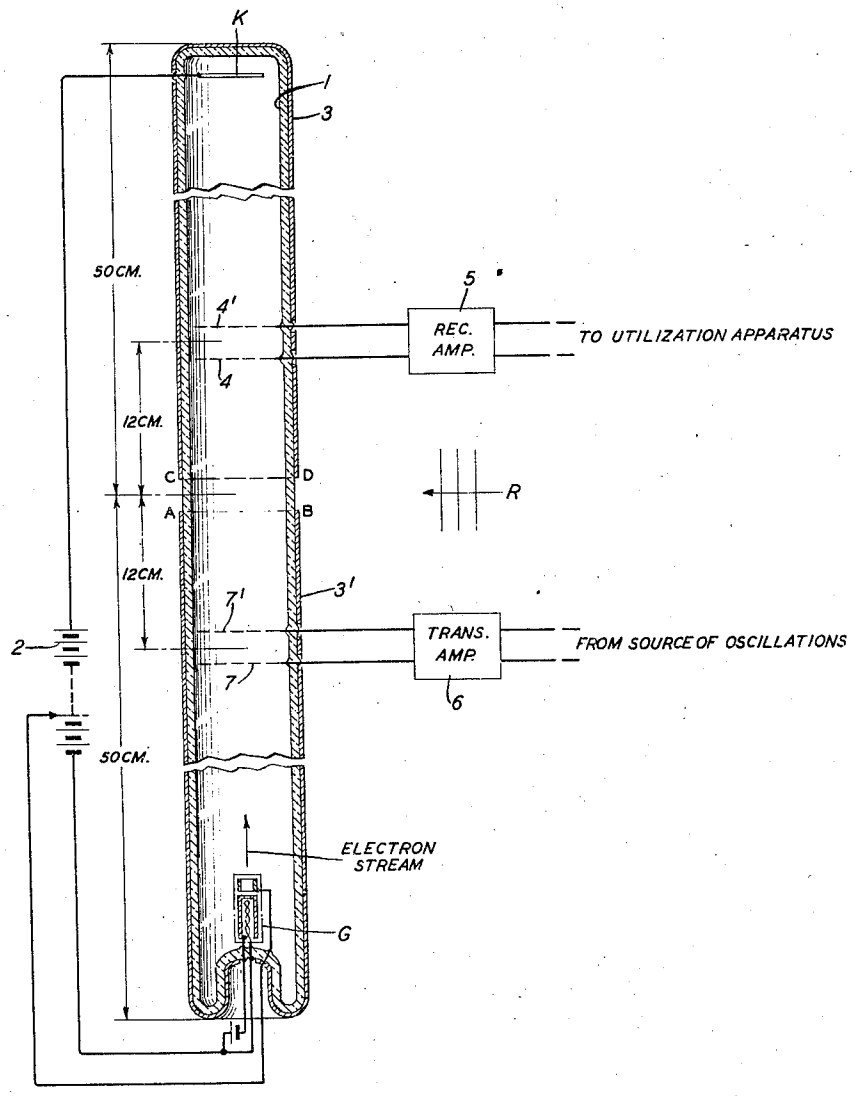

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DIPOLE ANTENNA

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This invention relates to dipole antennas useful for the radiation and reception of electromagnetic waves of wave-length 100 centimeters or less, particularly a dipole making use of velocity modulation of an electron stream for the direct transfer of energy from such a stream to a radiation field or vice versa.

Numerous expedients are known for using velocity modulation of electron streams in the radiation or reception of ultra-high frequency energy but so far no device has been suggested for the direct interchange of such energy between the radiation field and the stream. Examples of known expedients are disclosed in United States Patents 2,190,515, February 13, 1940, to W. C. Hahn, and 2,247,338, June 24, 1941, to S. Ramo to which reference may be made for a description of the means for establishing an electron stream of which the velocity is to be modulated.

The present invention, however, has for its object to provide means for an immediate energy interchange, in either direction, between the antenna and the stream.

The invention will be understood from the following description read with reference to the accompanying drawing, the single figure of which represents a dipole antenna according to the invention.

In the figure an evacuated cylindrical glass tube 1, of over-all length equal to the wave-length of the radiation to be transmitted or received, includes an electron gun G and an electron collector K connected externally of tube 1 to battery 2 which provides a potential difference of, say 500 volts between gun G and collector K. Details of gun G, of collector K, and of the electrical connections to battery 2 are omitted, these being set forth in the patent to Ramo above referred to.

Tube 1 is coated externally with a conducting two-part metallic layer 3 and 3' which encloses tube 1 completely except for intervals left for electrical connections to battery 2 and others later described and except further for a cylindrical gap defined by the planes AB and CD transverse to the axis of tube 1. Conveniently, planes AB and CD are located 1 centimeter apart and symmetrically with respect to the transverse plane halving the length of tube 1.

It will be seen that metallic coatings 3 and 3' constitute a dipole antenna adapted to receive or radiate, most efficiently in the plane at right angles to the length of tube 1, radiations of 100-centimeter wave-length. Coatings 3 and 3' may, of course, be metallic layers deposited in any

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well-known way or may be more substantial metallic shells fabricated to enclose tube 1 and provided with appropriate apertures for electrical connections. Tube 1 may be external to the dipole elements, with only obvious changes from the arrangement in the figure.

Consider a radiation field R advancing in the direction shown by the arrow. If the wave-length of this radiation is 100 centimeters, a voltage loop will appear across the gap between the respective ends AB and CD of the elements of the dipole antenna. The electrons in the stream passing through tube 1 will experience velocity modulation under the influence of this voltage loop and as a result will become bunched in successive groups after passing the gap.

The electrons bunched in groups as just described continue toward collector K passing on their way a pair of grids 4 and 4'. Between these grids an alternating electromotive force of the frequency of the received radiation is developed by electrostatic induction from the passing electron bunches and this electromotive force may be applied by connections as shown to receiving amplifier 5 leading to any convenient form of utilization apparatus.

Likewise the dipole described may serve as a transmitting antenna provided that from any convenient source electrical oscillations of the resonant frequency are impressed through transmitting amplifier 6 on the pair of grids 7, 7'. Grouping of the electrons will in this case take place in the drift space between grids 7, 7' and the gap AB—CD resulting in a voltage loop across this gap whereby energy is radiated from the dipole, again with a maximum in the plane at right angles to the axis of tube 1.

In each case the described apparatus serves to effect the interchange of high frequency energy directly between the radiation field and the electron stream traversing tube 1, without any intermediate detecting or transforming equipment being required.

As an illustration a radiation of 100-centimeter wave-length has been considered. For this case suitable dimensions of the apparatus are as follows: Tube 1 is 100 centimeters in length while metallic dipole elements 3 and 3' are each 49.5 centimeters long to enclose both ends of tube 1 and leave the central gap 1 centimeter in axial length. The axial spacing between grids 4 and 4' and that between grids 7 and 7' are each suitably 1 centimeter. The diameter of dipole elements 3 and 3' is suitably a small fraction of their length, say 4 centimeters. The distance s between the

central plane of grids 7, 7' and gap AB—CD, which is also the distance between gap AB—CD and the central plane of grids 4, 4', is chosen on the basis of the following considerations:

By a well-known formula the

$$\text{Electron drift time in cycles} = \frac{500s}{\lambda\sqrt{V}}$$

where s and λ are in centimeters and V is the potential difference in volts through which the electrons move from gun G to collector K. In the operation of velocity modulation devices the drift time in cycles is required to be $n+0.75$, where n is an integer, normally chosen to be 2. Accordingly, with $V=500$ volts

$$\frac{s}{\lambda}=0.12$$

or where $\lambda=100$ centimeters $s=12$ centimeters.

While the invention has been described with specific reference to the reception or radiation of electromagnetic waves of 100-centimeter wavelength uniformly in a plane at right angles to the axis of the dipole antenna, those skilled in the art will need no particular instruction to adapt the invention to receive or radiate in other than this transverse plane and the numerical relations given enable the ready computation of apparatus dimensions for wave-lengths longer or shorter than that chosen for illustration. Moreover, other forms of energy transfer means may replace the grid pairs 4, 4' and 7, 7' without departing from the spirit of the invention.

What is claimed is:

1. The method of effecting the direct interchange of electrical energy between an electron stream and an externally generated radiation field which comprises establishing an alternating voltage loop in said field, generating a stream of electrons having a desired velocity, directing said stream in a path substantially parallel to the voltage gradient in the region of said loop and producing modulation of the velocity of said electrons in passing said loop.

2. A dipole antenna comprising two longitudinally aligned tubular members each of a length substantially equal to one-half of a desired wavelength, the members at their adjacent ends being separated by a short gap across which an electric field develops in consequence of excitation of the antenna at its natural resonance frequency, a cathode ray source within one of the members and a collector within the other member and externally connected electrically to the source whereby the cathode ray when passing the gap interacts with the electric field thereacross and energy transfer means within each of said tubular members adapted to be electrically connected to an external circuit.

3. Means for the reception of electromagnetic radiation including a dipole antenna exposed to said radiation, comprising two longitudinally aligned tubular members each of length substantially equal to one-half of a desired wave-length, said members being separated at their adjacent ends by a short gap across which an electric field develops in consequence of the excitation of the antenna at its natural resonance frequency by said radiation, a cathode ray source within one of said members, a collector of cathode rays within the other of said members and externally electrically connected to said source whereby the cathode ray when passing said gap interacts with the electron field across said gap and energy transfer means within said other member adapted to be electrically connected to an external receiving circuit.

4. Means for the radiation of electromagnetic energy including a dipole antenna comprising two longitudinally aligned tubular members each of length substantially equal to one-half of a desired wave-length, said members being separated at their adjacent ends by a short gap across which an electric field develops in consequence of the excitation of said antenna at its natural resonance frequency, a cathode ray source within one of said members, a collector of cathode rays within the other of said members and externally electrically connected to said source and means for exciting said antenna at its resonant frequency including means for effecting velocity modulation of said cathode rays prior to their passage across said gap.

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