April 7, 1953 W. W. SALISBURY 2,634,372

SUPER HIGH-FREQUENCY ELECTROMAGNETIC WAVE GENERATOR

Filed Oct. 26, 1949

FIG. 1.

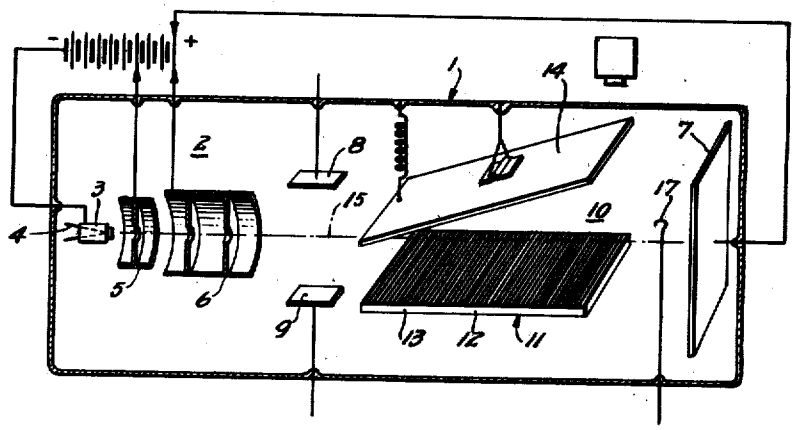


FIG. 2.

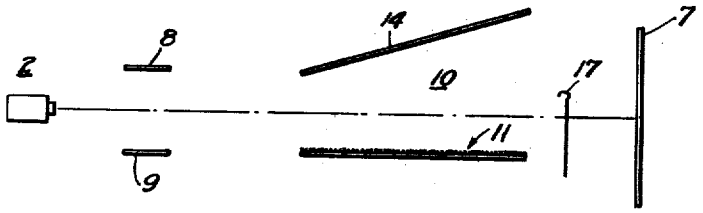


FIG. 3.

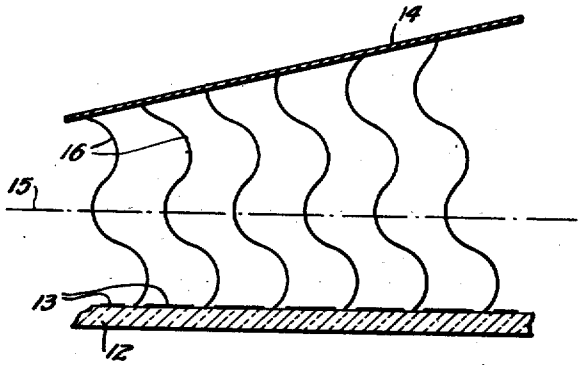
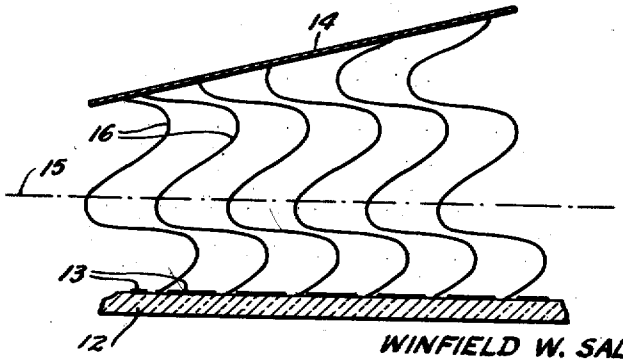


FIG. 4.



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SUPER HIGH-FREQUENCY ELECTROMAGNETIC WAVE GENERATOR

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12 Claims. (Cl. 250—36)

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This invention relates to electromagnetic wave generators, and more particularly to generators of the type employing interaction between an electron beam and electromagnetic field lines through which the beam passes.

A principal object of the invention is to provide a novel genertaor for electromagnetic waves of super high frequency, for example those of the order of a millimeter or less in wavelength.

Another object is to provide a novel generator of monochromatic or homogeneous radiation.

Another object is to provide a super high frequency electromagnetic wave generator employing an electron beam and a cooperating device for setting up standing electromagnetic wave patterns transversely of the beam.

A feature of the invention relates to the combination of a diffraction grating and a wave reflector for setting up standing electromagnetic wave patterns, and a source for producing and projecting an electron beam through said pattern to generate any desired monochromatic radiation.

Another feature relates to an electron discharge device having means to develop an electron beam of predetermined electron velocity, and a diffraction grating and wave reflector unit for setting up standing electromagnetic waves transverse to the beam trajectory to generate monochronmatic radiation.

Another feature relates to a monochromatic radiation generator employing means to develop an electron beam of predetermined electron velocity, and a unit excited by said beam and in the form of a diffraction grating and wave reflector to set up standing waves transverse to the beam trajectory, together with means for adjusting the trajectory angle of the beam with respect to the standing wave pattern to control the frequency of the desired monochromatic radiation.

A still further feature relates to the novel organization, arrangement and relative location of parts which cooperate to provide an improved monochromatic generator of radiations of the order of one millimeter or less.

Other features and advantages not particularly enumerated, will be apparent after a consideration of the following detailed description and the appended claims.

In the drawing,

Fig. 1 is a composite structural and schematic circuit diagram of a radiation generator according to the invention.

Fig. 2 is a simplified schematic showing of Fig. 1.

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Figs. 3 and 4 are magnified views of part of Fig. 1 explanatory of the invention.

There has been a great demand in certain fields of the radiation art, for an arrangement which can be used to generate homogeneous or monochromatic waves of super high frequency, for example in the range of one millimeter or less wavelength. The present invention provides such an arrangement and is predicated upon the interaction which takes place between a beam of electrons of predetermined velocity and trajectory, with respect to a standing electromagnetic wave pattern set up in the space through which the electron beam passes. In accordance with one feature of the invention, the desired standing wave pattern is produced by a diffraction grating and a cooperating wave reflector.

It is a well-known physical phenomenon that when a diffraction grating is excited in any of the well-known ways, for example by electromagnetic waves, each aperture or inter-line spacing in the grating acts in the nature of a minute energy radiation source, for example of electromagnetic waves. If the wave front of the exciting waves is parallel to the plane of the grating openings, then each opening may be considered as a separate wave source, with all the radiations from the several openings in like phase. If, however, a wave reflector is positioned at an angle with respect to the grating, there will be set up in the region between the grating and the reflector a standing wave pattern. Advantage is taken of this fact, by the present invention, to produce the desired monochromatic or homogeneous radiation. Thus the angle between the reflector and grating determines the frequency which will be reflected. A different frequency is obtained for each angular setting of the reflector.

Referring to Fig. 1, the numeral 1 represents any suitable enclosing bulb or envelope of glass or similar material which can be highly evacuated. Mounted within the bulb adjacent one end thereof, is an electron gun 2 of any construction well-known in the cathode-ray tube art. This gun may comprise, for example, an electron emitting cathode 3, with its indirect heater element 4 for heating the cathode to thermionic emitting temperature; a first beam-focussing and accelerating anode 5; a second beam-accelerating and focussing anode 6; and a cooperating electron collector electrode 7. Located between the gun 2 and collector 7, is a set of beam deflector plates 8, 9. Located between the deflector plates and the collector electrode 7, is a device 10 for setting up a standing wave pattern through which

the electron beam passes on its way to the collector.

In accordance with the invention, the device 10 comprises a diffraction grating 11 of any construction well-known in the optical art, and consisting of a multiplicity of spaced fine lines which are opaque to waves of the excitation frequency, and with the inter-line spaces transparent to such waves. For example, it may consist of a glass plate 12 on the planar surface of which there are provided the spaced electrically-conductive lines 13. The number of these lines per unit length of the plate 12, and the width of each line as well as the spacing between the lines should be chosen in accordance with the desired range of the output radiation frequency that is desired from the device. For example, 10,000 lines per centimeter may be used to give an inter-line spacing of .001 millimeter. The diffraction grating 11 is mounted so that the lines 13 extend transversely across the trajectory of the electron beam, and the deflector plates 8 and 9 are arranged so as to control the beam trajectory in a plane perpendicular to the plane of the diffraction grating.

Mounted in spaced relation to the grating 11 is a wave reflector 14 which may consist of a flat metal plate having a highly polished surface facing the diffraction grating 11, that is to say it is in the form of a mirror which has the property of reflecting the incident electromagnetic waves generated by the grating.

There is shown in Fig. 3, in magnified form, a portion of the grating and the reflector 14, showing how the standing wave pattern is set up between the grating openings and the reflector. When the grating is excited, the reflector 14 will be tuned by its angular position so as to reflect only one wavelength from the grating. This phenomena is well-known to the optics field. For example, the position of lines in an absorption spectrum may be obtained by allowing one of the lines to impinge on a diffraction grating, and noting the angle where the refraction from the grating is obtained. This is a well-known procedure for obtaining the wavelength of a particular visible radiation. Similarly in the present invention, the angle of the reflector picks up one wavelength from the diffraction grating and reinforces it, to obtain a standing wave pattern between the grating and the reflector. The electron beam which passes transversely through the standing wave pattern interacts with the electromagnetic wave produced by the grating, and increases its energy. Thus Fig. 3 shows the amplitude of the standing waves in the absence of the electron beam, and Fig. 4 shows the amplitude of the standing waves in the presence of the electron beam. The frequency of the standing wave between the reflector and the grating therefore does not change for a particular setting of the reflector. The electron beam passing therethrough, merely increases the amplitude of the standing wave pattern, or saying the same thing, it merely increases the energy contained in the standing wave. As the standing wave and the beam interact, the direct current beam of electrons which are passing through, tend to group or "bunch," as they say in the magnetron field, and this invention is of the nature of a very high frequency parallel plane magnetron. The energy is taken off by the pickoff 17, or by an energy receiver in the space between member 11 and member 7, and the energy increases directly as the velocity of the electron beam increases. In other words, by adjusting the positive potential of the electrode 7, or in any other way adjusting the velocity of the electrons in the beam 15, the amount of energy that can be picked up by the device 17 can likewise be controlled.

Thus for the dimensions of the grating lines and spaces as given above, the electrodes of the electron gun and the electrode 7 can be energized to produce a beam having electrons with an electron velocity of 50 kilovolts, and with the reflector 14 inclined at an angle of 20 degrees with respect to the plane of the grating to generate radiation frequencies of the order of 5,000 Angstrom units wavelength. It will be understood, of course, that in order to control the frequency of the generated monochromatic or homogeneous radiation, the angle between the reflector 14 and the diffraction grating can be adjustable. For example, the reflector 14 may be pivotally supported by a suitable member 18 from a wall of the envelope 1, and one end of the plate 14 may be urged upwardly by an appropriate spring 19, while the opposite end of the plate can be biased by means of a suitable electromagnet 20 external of the envelope. For this latter purpose, the plate 14 may be of magnetic material, or it may carry at its right-hand end a magnetic member which cooperates with the electromagnet 20.

The magnet 20, therefore, may be used as a means for modulating the frequency of the generated monochromatic radiation merely by applying corresponding varying excitations to the winding of the magnet 20.

The grating 11 does not require any external excitation source in order to initiate the action of the tube. Since the grating 11 is always at some temperature above absolute zero, there is enough energy radiated from it to initiate the operation of the tube as an oscillation generator when the cathode 3 is in operation and when the appropriate potentials are applied to the several electrodes as above described. However, it will be understood that if desired, the grating 11 may be excited by an external source of electromagnetic waves of any known type, the wavelength of which is correlated with the inter-lined spacing of the grating lines as is well-known in the diffraction grating art.

While certain embodiments have been described herein, it will be understood that various changes and modifications can be made without departing from the spirit and scope of the invention.

What is claimed is:

1. Super high frequency radiation generating apparatus, comprising means to develop a beam of electrons, means including a diffraction grating to set up a standing electromagnetic wave pattern through which the beam passes to produce a high frequency radiation controlled by the interaction between the beam and said pattern.

2. Super high frequency generating apparatus, comprising means to develop a beam of electrons, means including a diffraction grating and a cooperating wave reflector to set up a standing electromagnetic wave pattern through which the beam passes to produce a predetermined radiation frequency.

3. Super high frequency radiation apparatus, comprising means to develop a beam of electrons, a diffraction grating and a cooperating wave reflector for setting up a standing electromagnetic wave pattern through which the beam passes, and means to adjust the angular relation

between said grating and reflector to control the frequency of the generated radiation.

4. Super high frequency apparatus, comprising an evacuated enclosing envelope, an electron gun for developing a beam of electrons, an electron collector, and a device located between said gun and electrode for setting up a standing wave pattern through which the beam passes, said device including a diffraction grating.

5. Super high frequency apparatus, comprising an evacuated enclosing envelope, an electron gun for developing a beam of electrons, an electron collector electrode, and a device located between said gun and electrode for setting up a standing wave pattern through which the beam passes, said device including a diffraction grating, and a cooperating wave reflector.

6. The method of generating homogeneous electromagnetic wave radiation, which comprises developing an electron beam, setting up a standing electromagnetic wave pattern under control of a series of separate wave sources and a common wave reflector displaced along the beam trajectory, and controlling the angular relation between said sources and reflector to determine the radiation frequency, said pattern being set up by interaction between a diffraction grating and a wave reflector.

7. The method of generating homogeneous electromagnetic wave radiation, which comprises developing an electron beam, setting up a standing electromagnetic wave pattern under control of a series of separate wave sources and a common wave reflector displaced along the beam trajectory, and controlling the angular relation between said sources and reflector to determine the radiation frequency, the frequency of the radiation being controlled by adjusting the angular relation between a diffraction grating and a cooperating reflector between which the electron beam passes.

8. The method of generating homogeneous radiation, comprising developing a beam of electrons, exciting a diffraction grating by the electromagnetic waves from said beam to set up a

standing wave pattern along said grating, passing said beam through said pattern, and adjusting said pattern in accordance with the desired radiation frequency.

9. The method according to claim 8, in which the standing wave pattern is set up between said diffraction grating and a cooperating wave reflector.

10. A super high frequency tube, comprising an evacuated envelope, said envelope containing an electron gun, an electron collector electrode, a diffraction grating extending parallel to the electron beam between the gun and collector, a reflector member cooperating with said diffraction grating to set up therebetween a predetermined standing wave pattern, and means within the envelope to conduct the generated radiation to a point external of the envelope.

11. A tube according to claim 10, in which means are provided to control the frequency of the standing waves.

12. A tube according to claim 10, in which said reflector is mounted in angular spaced relation with respect to said grating, and means are provided for adjusting the said angular relation and thereby to determine the frequency of the generated radiation.

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