United States Patent

Nishino et al.

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[54] **ELECTRON BEAM DEFLECTING DEVICE**

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[52] **U.S. Cl.** .....**315/3,** 315/3.5, 313/83, 313/83 SP

[51] **Int. Cl.**.....**H01j 29/70,** H01j 25/36, H03h 7/30

[58] **Field of Search** ....315/3, 3.5, 3.6; 313/83, 83 SP

[56] **References Cited**

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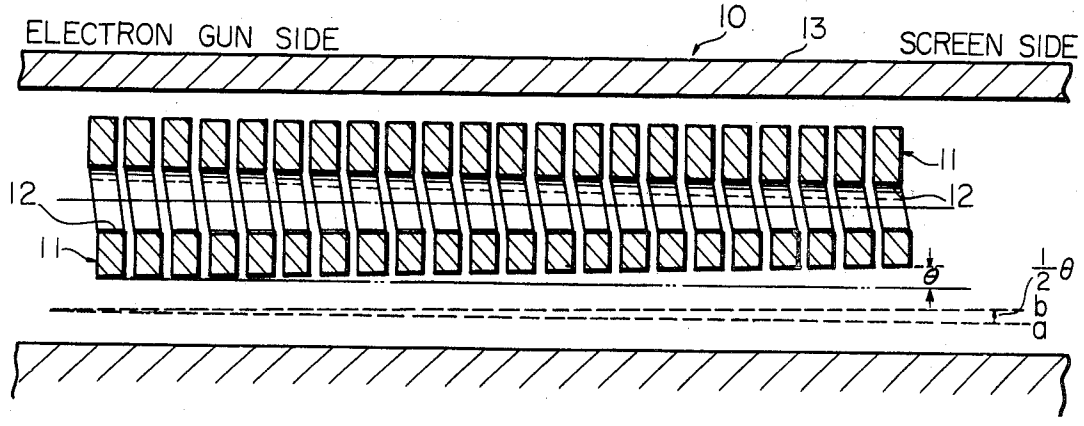
[57] **ABSTRACT**

A device for deflecting an electron beam emitted from an electron gun in a cathode-ray tube, the device being of the type having a helical strip slow-wave structure, wherein the improvement resides in enlarging the passage of the electron beam toward the display screen of the cathode-ray tube with the characteristic impedance of the slow-wave structure maintained constant throughout the length of the slow-wave structure.

1 Claim, 3 Drawing Figures



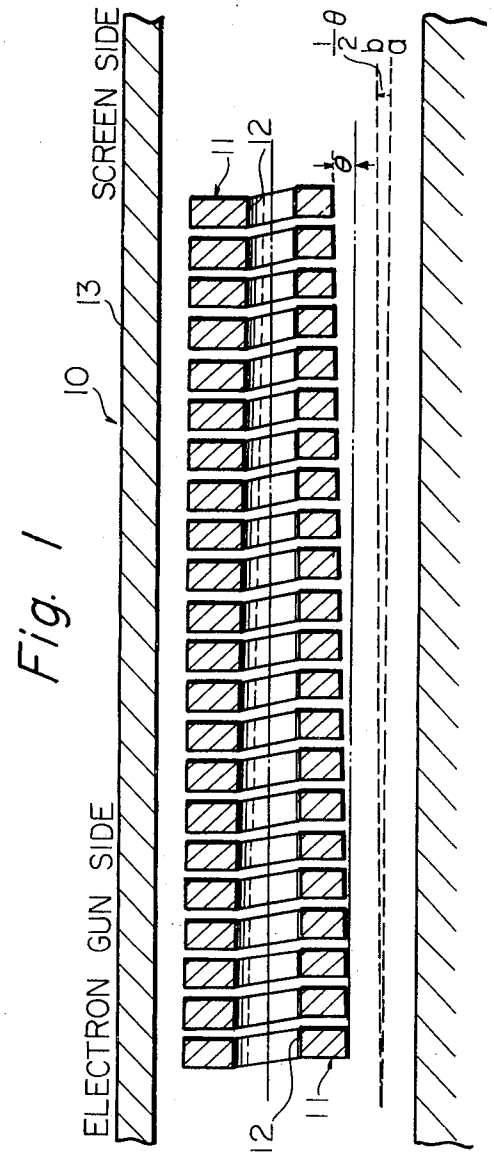


Fig. 1

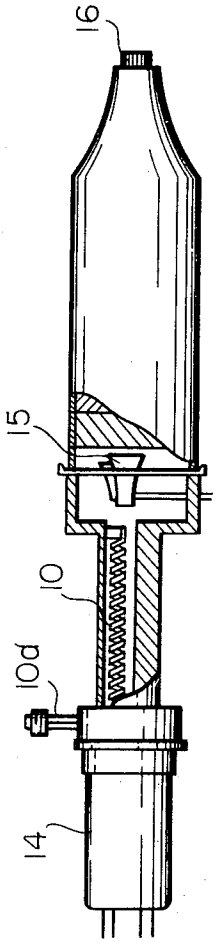


Fig. 2

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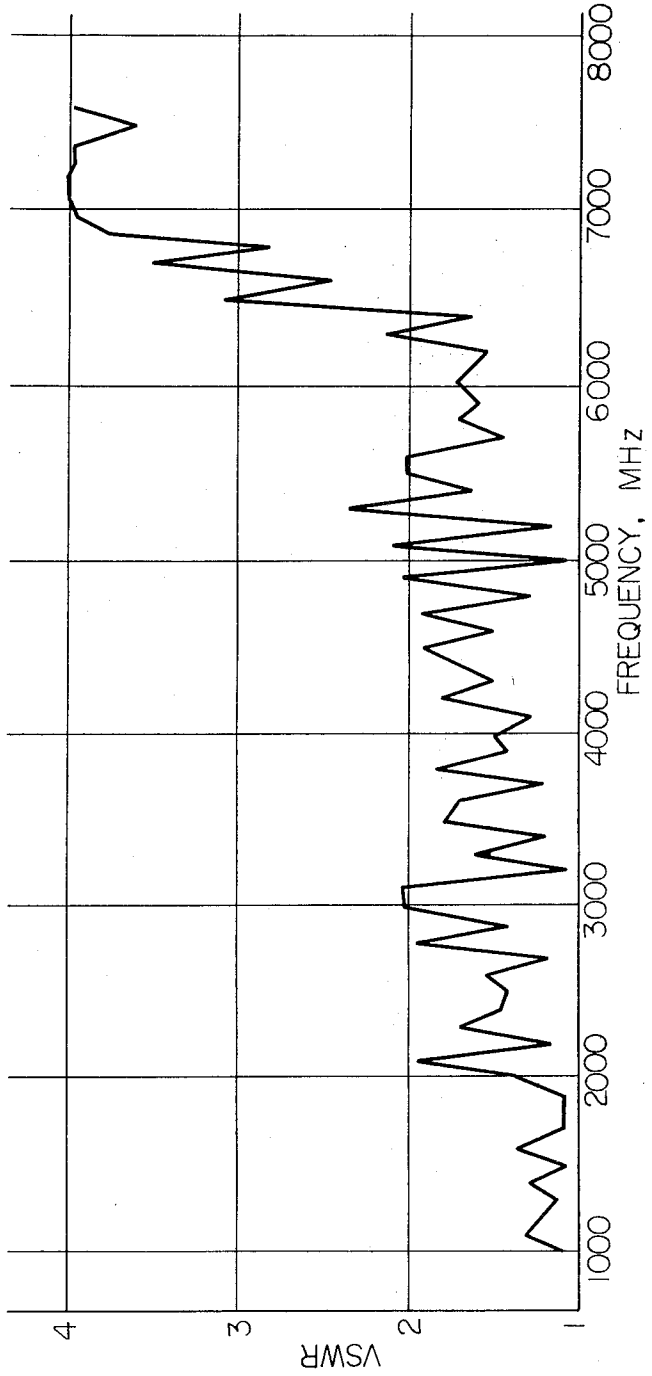
Fig. 3



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ELECTRON BEAM DEFLECTING DEVICE

This invention relates to an electron beam deflecting device for use with a cathode-ray tube for the display of waveforms and, more particularly, to an electron beam deflecting device of the type using a helical strip slow-wave structure.

A deflecting device having parallel-plate electrodes is used in a cathode-ray tube for the direct observation of single-pulse waveforms with an ultra-high frequency and ultra-fast waveforms consisting of ultra-wide band frequency components. Degradation in deflection sensitivity and an inverted deflection of the electron beam is inverted during the electron transit time in the device of this type. A deflecting device using a helical strip slow-wave structure is, therefore, used in lieu of such conventional device so as to avoid these and other difficulties, providing a uniform deflection sensitivity over a range d.c. to thousands of mega-hertz. Since, however, an amplifier providing a uniform amplification characteristics over such an ultra-wide band is not presently available, drawbacks are still encountered in this advanced deflecting device in that it is practically impossible to reduce the axial length of the device to the order of 3 to 4 centimeters as in a usual parallel-plate deflecting device of a low-frequency cathode-ray tube and to have the passage of the electron beam enlarged progressively toward a screen on which the waveforms are to be displayed. One of the reasons accounting for such drawbacks is that the passage of the electron beam should be narrowed as much as possible for increasing the deflection sensitivity and that the physical length of the helical strip slow-wave structure should be elongated to the order of a deflecting action by a travelling-wave electric field for an extended time duration. Another reason is that the characteristic impedance and the phase-velocity characteristics of the helical strip slow-wave structure should be uniform throughout the longitudinal direction of the helical strip slow-wave structure. The effective scanning area of the display screen is thus limited significantly notwithstanding the fact that a deflection sensitivity of several volts per centimeters is available with the deflecting device of the conventional helical strip slow-wave structure type.

It is therefore an object of this invention to provide an improved electron beam deflecting device of the type using a helical strip slow-wave structure wherein the passage of the electron beam is enlarged toward the display screen of the cathode-ray tube and consequently the effective scanning area of the screen can be increased, without inviting a substantial variation in the characteristic impedance of the helical slow-wave structure.

In the drawings:

FIG. **1** is a longitudinal sectional view of an essential part of a travelling-wave deflection device implementing this invention;

FIG. **2** is a schematic view showing an example of the applications of the device shown in FIG. **1**; and

FIG. **3** is a plot showing the characteristic impedance VSWR (voltage standing wave ratio) of the device illustrated in FIG. **1**.

Referring to FIG. **1**, the electron beam deflecting device according to this invention, which is generally represented by reference numeral **10**, comprises a helical strip slow-wave structure **11** having an internal bore

12 extending therethrough. The slow-wave structure **10** is enclosed in a cylindrical outer conductor **13**. In an existing electron beam deflecting device using a helical strip slow-wave structure, the slow-wave structure and the outer conductor are in coaxial relationship with each other and the electron beam advances in a direction through a passage defined between the two members, the direction of the electron beam being indicated by a broken line *b*. The combination of the structure **11** and the outer conductor **13** used as the electron beam deflecting device is know per se.

According to this invention, now, the helical strip slow-wave structure **11** is tapered forwardly on its side defining the passage of the electron beam. The structure **11** is herein shown as tapered at an angle θ which may be selected as desired. In order that the passage of the electron beam be symmetrical with respect to the center line of the beam advancing therethrough, the axis of the cylindrical outer conductor **13** should be inclined at an angle corresponding to one-half of the angle θ in an opposite direction. As a result, the center line of the passage of the electron beam is relatively deviated at an angle $\theta/2$ as indicated by a broken line *a*.

The passage of the electron beam thus being enlarged, the impedance and the phase characteristic of the helical strip slow-wave structure will be varied toward the outlet of the deflecting device failing to provide a uniform transmission characteristics throughout the length of the deflection device. To avoid this difficulty, the bore **12** in the helical structure **11** may be forwardly reduced in diameter so that the reduction in the capacitance resulting from the tapering of the structure **11** is compensated for by decreasing the inductance.

FIG. **2** sketchily illustrates an example of applications of the electron beam deflecting device of FIG. **1** in a cathode-ray tube. As shown, an electron beam is emitted from the electron gun **14** and deflected vertically when passing through the travelling-wave deflection device **10**. The thus deflected beam is further deflected horizontally by the horizontal deflector means **15** and the resultant optical information such as waveforms is displayed on a screen **16** as customary. Designated by reference numeral **10***a* is an input plug of the travelling-wave deflection device **10**.

It will now be appreciated from the foregoing description that the screen **16** can be scanned over an increased area because of the enlarged passage of the electron beam in the travelling-wave deflection device **10** without inviting a variation in characteristic impedance throughout the length of the device **10**. As a matter of fact, the characteristics impedance of the deflecting device according to the invention is maintained comparable to that attained in the conventional counterpart, as will be understood from observation of FIG. **3**.

What is claimed is:

1. A device for deflecting an electron beam emitted in a direction from an electron gun, which comprises:

a cylindrical outer conductor the central axis of which is inclined at an angle from said direction; and

a helical strip slow-wave structure having an axial bore extending therethrough and a predetermined radial thickness and positioned axially within said

cylindrical outer conductor so as to define a passage between one side surface of said slow-wave structure and the inner wall of said outer conductor through which said electron beam is permitted to pass; said one side surface of said slow-wave structure being tapered along said direction at an angle corresponding to twice of the angle at which said outer conductor is inclined from said direction; and said bore being reduced in diameter in said direction.

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