United States Patent

Kantorowicz

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[54] **DELAY LINES**

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[52] **U.S. Cl.** .....**315/3.5,** 315/39.3, 315/39.73, 333/31 A

[51] **Int. Cl.**.....**H03h 7/30**

[58] **Field of Search**.....315/3.5, 3.6, 39.3, 39.73; 333/31 A

[56] **References Cited**

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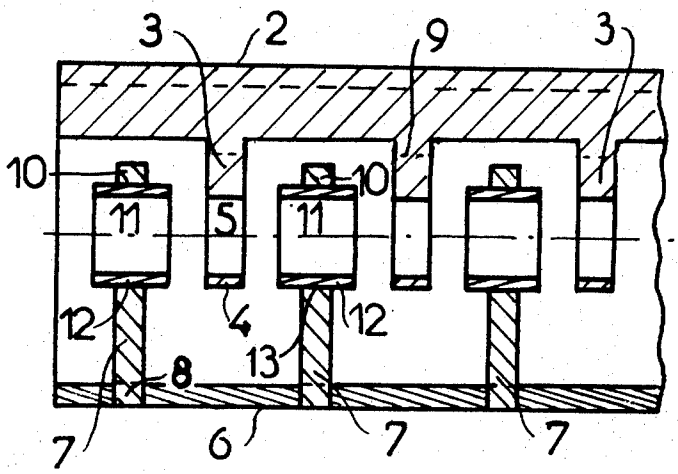
[57] **ABSTRACT**

This asymmetrical interdigital delay line is constituted by two combs of triangular interleaved fingers of different dimensions, with the fingers of one comb provided near their extremities with a hole, while those of the other comb are provided near their tips with a tube of a width larger than the thickness of the fingers, the axis of the tube coinciding with the axis of the holes and that of the beam passing through the delay line in operation, this structure bringing the advantages of direct fundamental mode operation and good heat dissipation.

6 Claims, 5 Drawing Figures



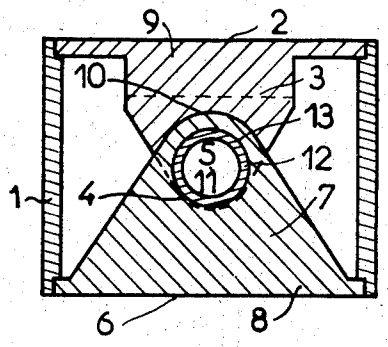


Fig 1

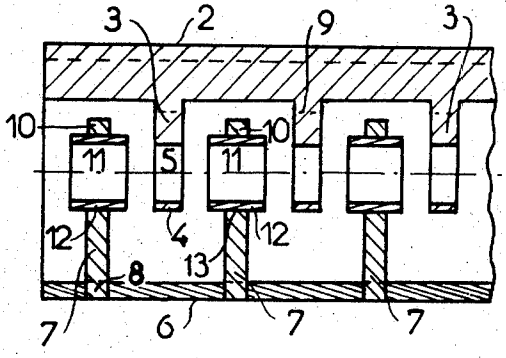


Fig 2

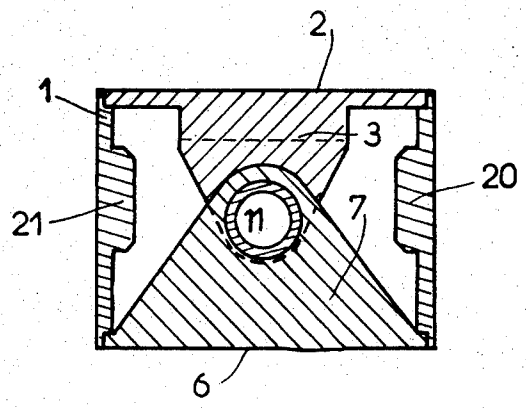


Fig 5

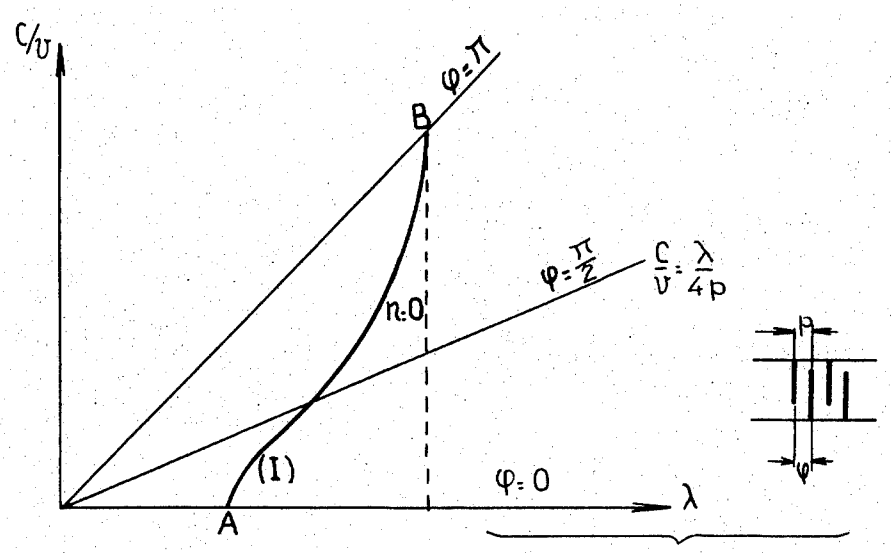


FIG 3

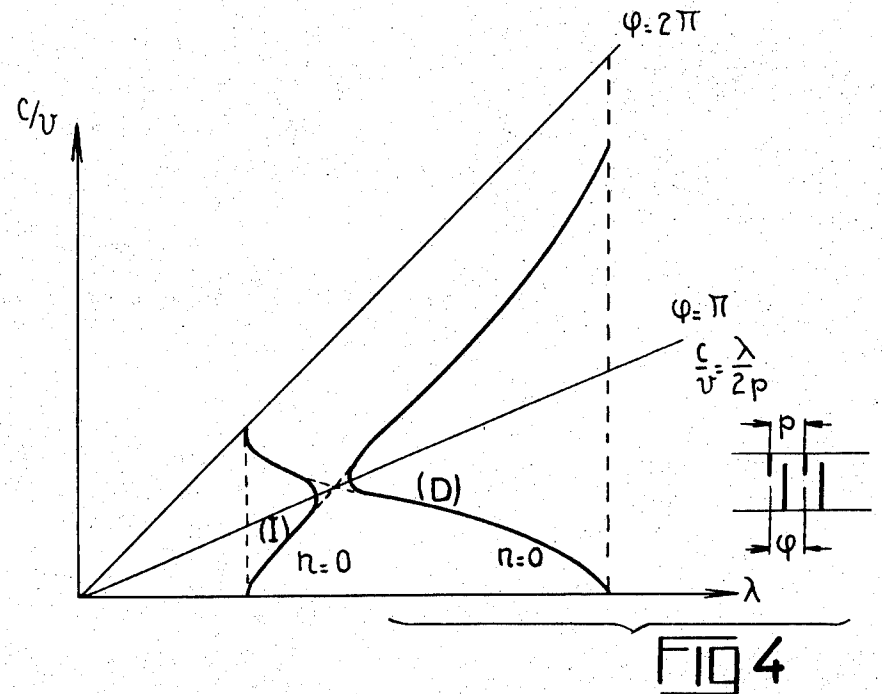


FIG 4

DELAY LINES

The present invention relates to asymmetrical interleaved or otherwise known as interdigital delay lines, operating in the fundamental mode, and intended for travelling wave tubes.

It is an object of the invention to provide a delay line of this type having the advantages of low dispersion, wide pass band, good heat dissipation, solid structure and straightforward manufacture.

According to the invention, there is provided a delay line comprising two-comb shaped structures, facing each other and having interleaved fingers, generally shaped as triangles and having aligned openings defining a rectilinear passage for the transfer of an electron beam, said structures being asymmetrical with respect to the axis of said tube.

For a better understanding of the invention and to show how the same may be carried into effect, reference will be made to the ensuing description and the drawings which accompany it, in which:

FIGS. 1 and 2 respectively illustrate a transverse and a longitudinal section through a delay line in accordance with the invention;

FIG. 3 illustrates the dispersion characteristic of a symmetrical interleaved delay line;

FIG. 4 illustrates the dispersion characteristic of an asymmetrical delay line in accordance with the invention; and

FIG. 5 illustrates a variant embodiment of a delay line in accordance with the invention.

In FIGS. 1, 2 and 5, similar elements are indicated by the same references.

FIGS. 1 and 2 illustrated a metal envelope 1 of reentrant rectangular cross-section, equipped on one of its faces 2 with a series of triangular fingers 3 provided in the neighborhood of their tips 4 with a hole 5, whilst the opposite face 6 of the envelope 1 carries another series of triangular fingers 7 whose base width 8 is larger than the base width 9 of the fingers 3 in the first series. The fingers 7 are provided in the neighborhood of their tips 10 with a tubular structure 11 produced by inserting a tube 12 into an opening 13 formed in the finger 7. The tube 12, disposed perpendicularly to the plate forming the finger 7 and symmetrically in relation to the said finger, is placed in position there. The axis of the tube 12 coincides with the axis of the holes in the fingers 3.

In operation, the axis of the beam passing through the delay line will coincide with the common axis of the holes 5 and the tubes 12.

The tubes 12, which are parallel with the beam, form with the immediately adjacent fingers, a local capacitance which increases the coupling resistance between the beam and line. The difference between the length of the fingers in the respective series, as well as the difference in their base widths, make it possible to achieve low dispersion in the direct fundamental mode.

An analysis of FIGS. 3 and 4 clearly shows the difference between the operation of a conventional symmetrical interleaved delay line shown in FIG. 3 and that of an asymmetrical interleaved delay line as described above. In this latter case the triangular shape of the fingers, the asymmetry of their dimensions and the asymmetry in the position of the two comb conductors in the metal envelope, ensures low dispersion at the direct fundamental mode and a wide pass band.

In other words, if two adjacent fingers are identical, (symmetrical line) the dispersion curve, representing the variations in the delay ratio c/v of the line as a function of the wavelength λ (c being the velocity of light and v the speed of propagation of the wave along the delay line), is "backwards" in the fundamental mode (part I of the curve plotted in FIG. 3); that is to say, c/v increases as the frequency reduces, this very rapidly indeed. The phase-shift between two immediately adjacent fingers varies between 0 and π when passing from the high frequency cu-off point (A) to the low frequency cut-off point (B) of the line.

If now the curve of FIG. 4 is considered, this corresponding to an asymmetrical delay line, it will be seen that the fundamental mode has a cut-off point for a phase-shift of $\pi/2$ between two immediately adjacent fingers, that is to say π between two identical consecutive fingers. This fundamental mode has a direct dispersion (section D of the curve in FIG. 4); calling p the pitch of the line, that is to say the distance separating two identical consecutive fingers, then one will have a cut-off point $c/v = \lambda/2p$.

This fundamental mode thus exhibits direct dispersion (section D), in respect of which the electron beam is coupled to the wave having the same delay ratio, and backwards dispersion behavior (section I) in respect of which the beam is coupled to a wave of higher frequency.

The line will advantageously be operated in the portion of the curve corresponding to section D, which exhibits a low dispersion.

This delay line in accordance with the invention has the advantage of good heat dissipation, thanks to the solid bases of the triangular fingers. The heating of the line, consequent upon its bombardment by the electrons of the beam or upon high frequency losses, is thus maintained within suitable limits, in particular if high power tubes are considered.

Another advantage of the delay line described is that it can easily be manufactured by milling the triangular fingers out of a solid block and that it has a reduced number of base connections. It is worth adding that under these circumstances, the inherent attenuation of the line is reduced, something which is very important in the case of lines having to operate at very high frequencies.

Of course, the invention is in no way limited to the embodiments described hereinbefore. It will be observed in particular that it may be advantageous, in order further to increase the pass-band, to choose a rectangular section envelope having a re-entrant profile on three of its faces as shown in FIG. 5, that is to say on the face 2 carrying the fingers 3 and on the faces 20 and 21. A structure of this kind modifies the dispersion characteristics of the line and makes it possible to achieve low dispersion throughout the wide frequency band.

What is claimed is:

1. An interdigital delay line comprising two comb-shaped structures, defining an exterior tube facing each other and having asymmetrical interleaved fingers, generally shaped as triangles and having aligned openings defining a rectilinear passage for the transfer of an electron beam, said structures being asymmetrical with respect to a central axis of said exterior tube, the fingers of one of said structures carrying respective

tubes inserted in said openings, the length of said tubes being greater than the thickness of the fingers.

2. The delay line as claimed in claim 1, wherein the length of the bases of said triangles in one of said structures differs from that in the other structure.

3. The delay line as claimed 1, wherein the height of said triangles in one of said structures differs from that in the other structure.

4. The delay line as claimed in claim 1 further including laterally disposed means mounted to said exterior tube in substantial alignment with said rectilinear passage for modifying the dispersion characteristics of the electron beam transferred through the delay line.

5. The delay line as claimed in claim 4 wherein said laterally disposed means includes two faces of generally rectangular cross-section shape protruding into said exterior tube.

6. The delay line as claimed in claim 1, wherein the size of each of the interleafed fingers of each of the comb-shaped structures is equal to those of their respective structure but different from those of the other structure, so as to provide asymmetry with respect to the central axis of the exterior tube.

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