United States Patent [19]

Guillemet et al.

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[54] **DELAY LINES COOLED BY LIQUID CIRCULATION AND ELECTRONIC TUBES UTILISING SUCH DELAY LINES**

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[52] **U.S. Cl.** **315/3.5,** 313/30, 313/31

[51] **Int. Cl.** **H01j 25/34**

[58] **Field of Search** 313/30, 31, 32; 315/3.5

[56] **References Cited**

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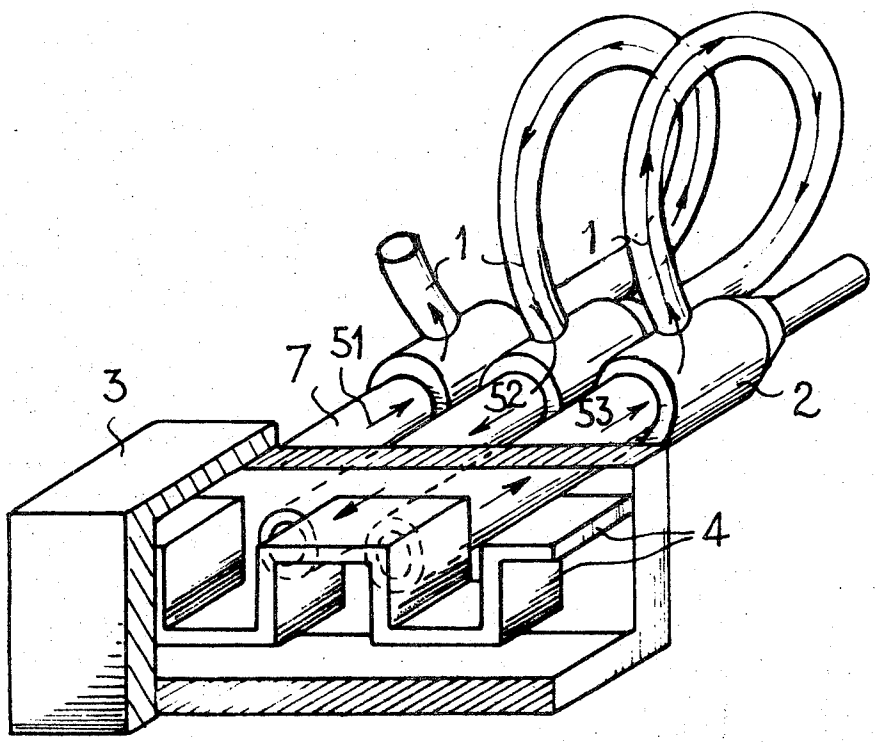
[57] **ABSTRACT**

Delay line in the form of a helix for a travelling wave tube is provided including a plurality of hollow conductive tube elements forming turns of the helix. Fluid distribution means communicates with the tube elements for circulating fluid therethrough and includes alternate feeds to each of said turns and alternate outputs from each of said turns, said alternate feeds and outputs forming conductive elements coupled to the extremities of each of the conductive tube elements of the helix.

5 Claims, 5 Drawing Figures



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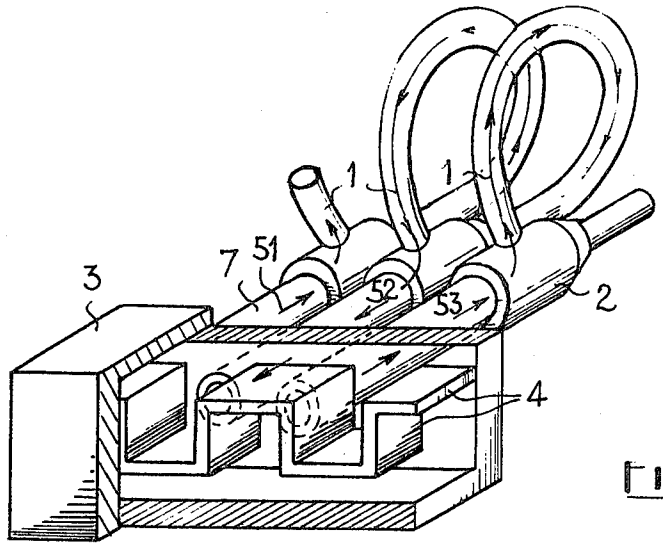

FIG. 1

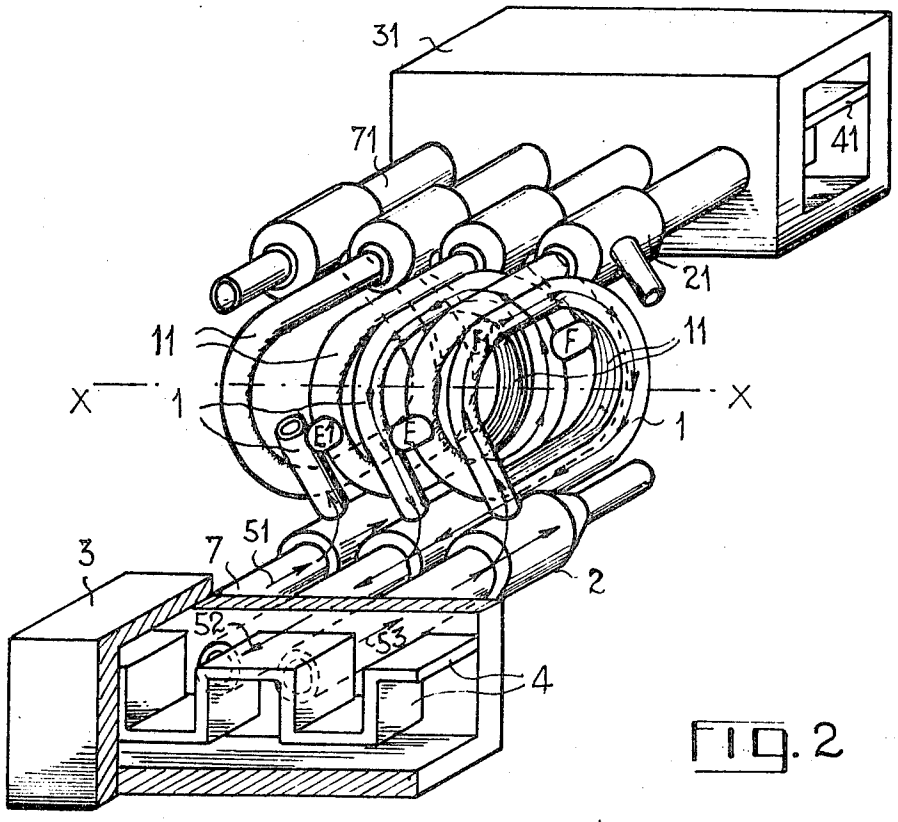

FIG. 2

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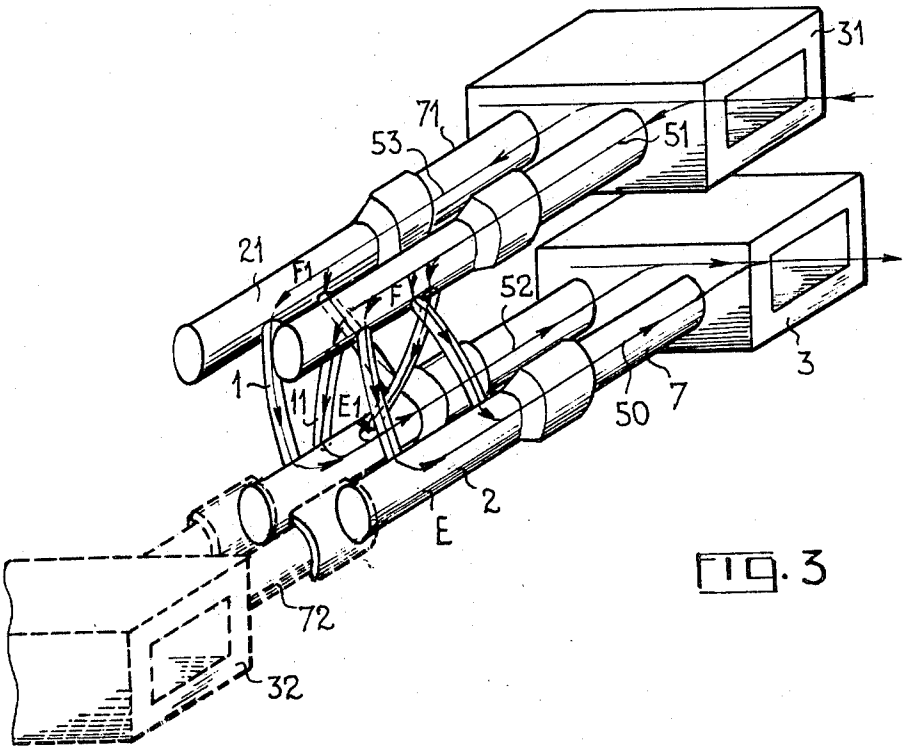

FIG. 3

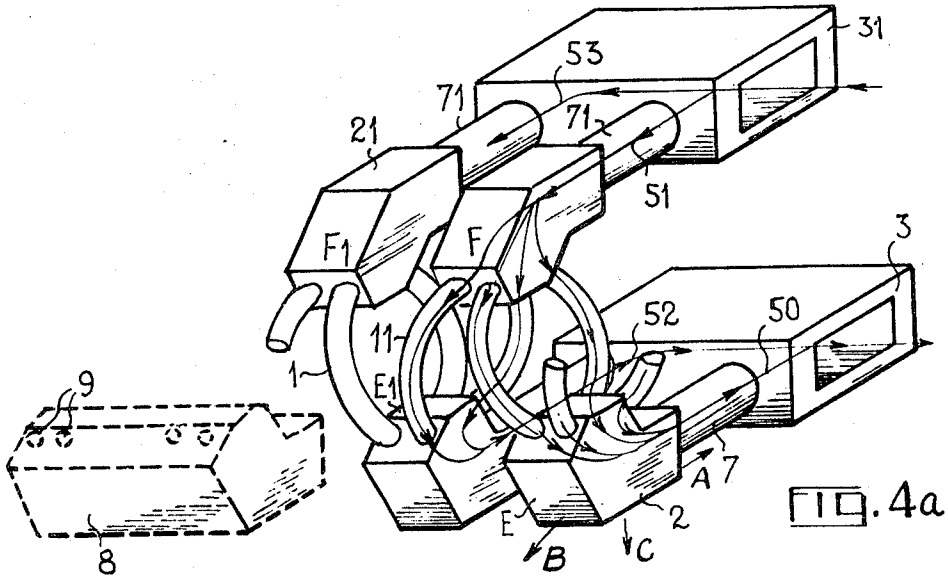

FIG. 4a

FIG. 4b

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DELAY LINES COOLED BY LIQUID CIRCULATION AND ELECTRONIC TUBES UTILISING SUCH DELAY LINES

The present invention relates to delay lines cooled by liquid circulation, as utilised in travelling wave tubes.

It is well-known in the context of the operation of delay lines inside travelling wave tubes, that highly efficient cooling of the delay line is necessary in order to achieve high performance figures.

This cooling problem is not a major one in delay lines in low power tubes, the heat dissipation through the line support generally being adequate. By contrast, considering delay lines for high power tubes, this kind of cooling system is inadequate to dissipate the whole of the heat energy produced and it is more generally usual to increase the heat dissipation of the line by using liquid circulation cooling, the liquid genrally being a dielectric one for electrical reasons. This is the case for example in the structure disclosed in U. S. Patent Application Ser. No. 114,465 filed Feb. 11, 1971. However, in the prior art, generally it is only certain parts of the line which are accessible to the cooling liquid, the other parts being cooled by thermal conduction through their supporting components. These components, which are insulators for electrical reasons, have poor thermal conductivity and there fore only provide mediocre cooling.

The object of the present invention is to overcome this drawback by making the whole of the line accessible to the cooling liquid.

The present invention relates to a helical delay line characterised in that each of the turns of said line is constituted wholly by a hollow conductor through which the cooling liquid flows.

The invention will be better understood from a consideration of the ensuing description and the attached FIGS. which have been given purely by way of non-limitative example and in which identical symbols designate identical elements :

FIG. 1 is a fragmentary perspective view of a single helix delay line of the present invention.

FIG. 2 is a fragmentary perspective view of two of the single helix delay lines and FIG. 1 forming another embodiment of the present invention.

FIG. 3 is a fragmentary perspective view of yet another delay line utilizing the inventive concepts herein.

FIG. 4*a* is a variation of the embodiment of FIG. 3.

FIG. 4*b* is a detail of a portion of the embodiment of FIG. 4*a*.

FIG. 1 provides a fragmentary perspective view of a single helix delay line 1 in accordance with the invention, associated with a cooling fluid distributor 3 with baffles 4, through the medium of components 2 and 7. The helix proper, is constituted by an assembly of bent metal tubes 1 connected with one another by conductive components 2. The cooling fluid, a dielectric liquid, for example, is supplied to the line by the distributor 3; its circuit has been indicated by arrows 51, 52, 53 showing the fluid inputs 51 and 53 and the return 52 through the insulators 7.

FIG. 2 illustrates by way of example how, using two single helix delay lines as indicated earlier in FIG. 1, another delay line in accordance with the invention can be formed, comprising two helices with a mutual axis XX. The difference in the shape of the bent metal tubes of FIGS. 1 and 2, is due to the ovalization of the turns

which is designed to enable the interpenetration of the two helices, due to their relatively small pitches. As in the case of the delay line of FIG. 1, the elements which make up said helices consist of metal tubes 1 and 11 previously shaped and connected to the fluid distributors 3 and 31 through the medium of conductor sections 2 and 21 and ceramic tubes 7 and 71. The two helices are connected by electrically conductive bars E, E1, F F1 etc. . . at their closest point.

FIG. 3 illustrates another example of a delay line in accordance with the invention, again using bent metal tubes 1, 11. The bars E, E1, F, F1 in this case are integral with the conductor sections 2, 21 whereas in FIG. 2 they were separate elements ; on the other hand, the cooling fluid pipes are simplified: the inputs 51, 53 and the returns 50, 52 for the fluid are separate and no longer alternate in the same input and output distributor as in FIG. 1, so that the fluid distributors 3 and 31 no longer require baffles. The inputs 2 and 7 and outputs 21 and 11 are coupled alternately to each of the turns similarly as in FIG. 1. The fluid distributors can, thanks to the arrangement of the conductors 2, 21, be provided either with an input 31 and the return 3 at the same side or with an input 31 and the return 32 at opposite sides. The elements of this kind of line are assembled together by welding.

The delay line shown in FIG. 4*a* is a variant embodiment of that of FIG. 3, in which we encounter once again the bent tubes 1, 11 and the bare E, E1, F, F1 which are integral with the conductor sections 2, 21 connected to the fluid distributors 3, 31 by the ceramic tubes 7, 71. The inputs 51, 53 and the returns 50, 52 for the fluid are marked by the arrowhead lines. An assembly of this kind provides a choice in the positioning of the fluid distribution circuits ; for example, the circuit 3 positioned for fluid output in the direction A, can be rotated through 180° for output in the direction B, through 90° for output in the direction C, or can for that matter be disposed in any other intermediate position. The delay line shown in FIG. 4*a* is indistinguishable from that of FIG. 3 except for the replacement of the sleeves and straight tubes constituting the conductor sections 2, 21 by components of different shape. The advantage of this arrangement resides in the great flexibility of positioning of the fluid distributors and also in the improved mechanical strengh during the operations of manufacture of the line.

In the case of this example, the preparation of the line is effected as follows : The distributors 3, 31 are equipped with ceramic tubes 7, 71 for example brazed to the respective distributors. All the ceramic tubes 7, on the one hand and 71 on the other, are connected, likewise by brazing, for example to two bars such as the bar 8 in FIG. 4*b*, in the case of the tubes 7. These bars are prevously drilled in order to allow the metal tubes 1, 11 (orifices 9 in FIG. 4*b*) to communicate with the ceramic tubes 7 and 71.

In order to complete the preparation of the line, all that is required is to cut off the bars to produce the components E, E1, F, F1 of FIG. 4*a*, this operation being carried out by one of the known techniques, for example spark-machining.

The invention is in no way limited to the examples described. The metal tubes 1, 11 as shown in FIGS. 1, 2, 3, 4*a* may consist of tubes of an insulating material coated externally with an electrically conductive layer; the same applies to the conductor sections 2, 21.

The invention also somprises the electronic tubes, whatever their other specifications, embodiying delay lines in accordance with the invention.

Of course, the invention is not limitated to the embodiment described and shown which was given solely way of example.

What is claimed is:

1. A delay line in the form of a helix for a travelling wave tube including:

a plurality of hollow conductive tube elements forming turns of the helix;

a fluid distributor communicating with the tube elements for circulating cooling fluid therethrough including, alternate feeds to each of said turns and alternate outputs from each of said turns, said alternate feeds and outputs formed of conductive elements coupled to extremities of each of the tube elements of the helix.

2. The delay line as recited in claim **1** comprising:

a second helix interspaced with said first mentioned helix, each turn thereof coupled alternately with the input and output feeds; and further including:

electrically conductive bars for coupling each turn of said first mentioned helix with an adjacent turn of the second mentioned helix.

3. The delay line as described in claim **2** wherein each of said bars are hollow, attached with the conductive portions of said turns and communicate with the cooling fluid.

4. The delay line as described in claim **1** is disposed in the travelling wave tube such that an electronic beam generated by the travelling wave tube travels down the axis of the helix amplifying a radio frequency wave traveling along the helix interacting therewith.

5. The delay line as described in claim **1**, further including insulating material of a ceramic type covering an external conductive layer of said input and output feeds for each of said turns.

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