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2,293,152

VELOCITY MODULATED TUBE WITH REMOVABLE RESONATOR

Filed Oct. 15, 1940

2 Sheets-Sheet 1

FIG. 1.

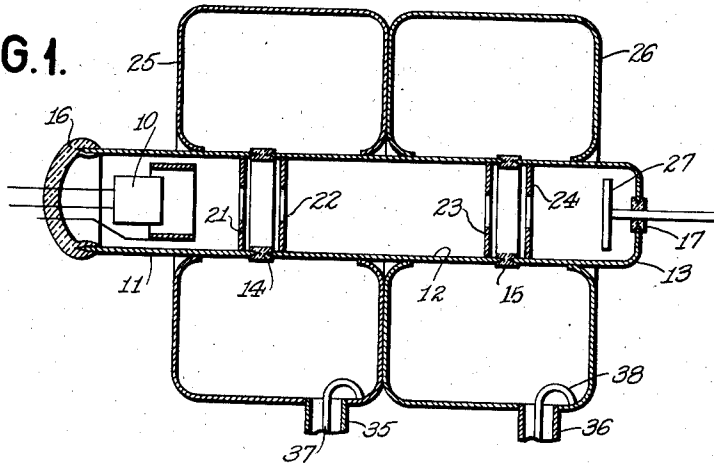


FIG. 2.

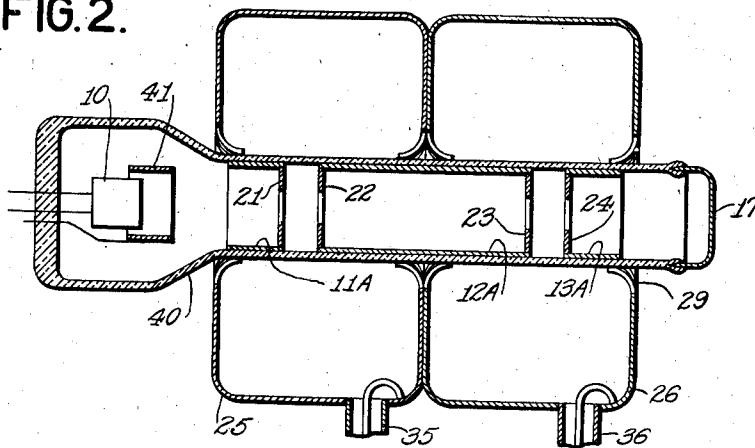
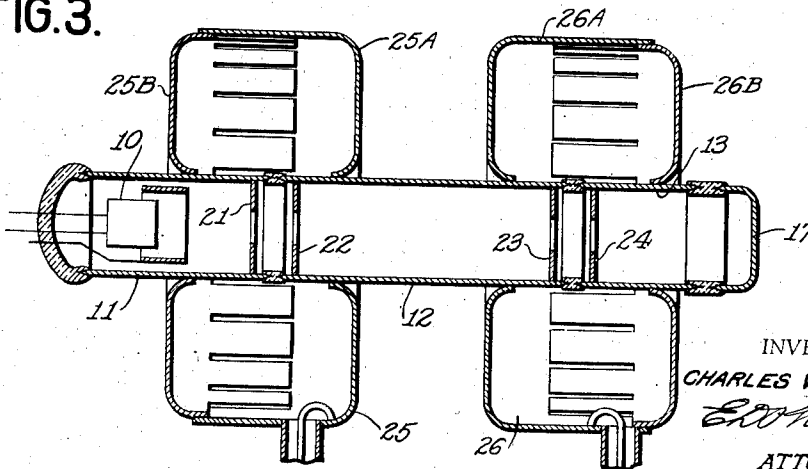


FIG. 3.



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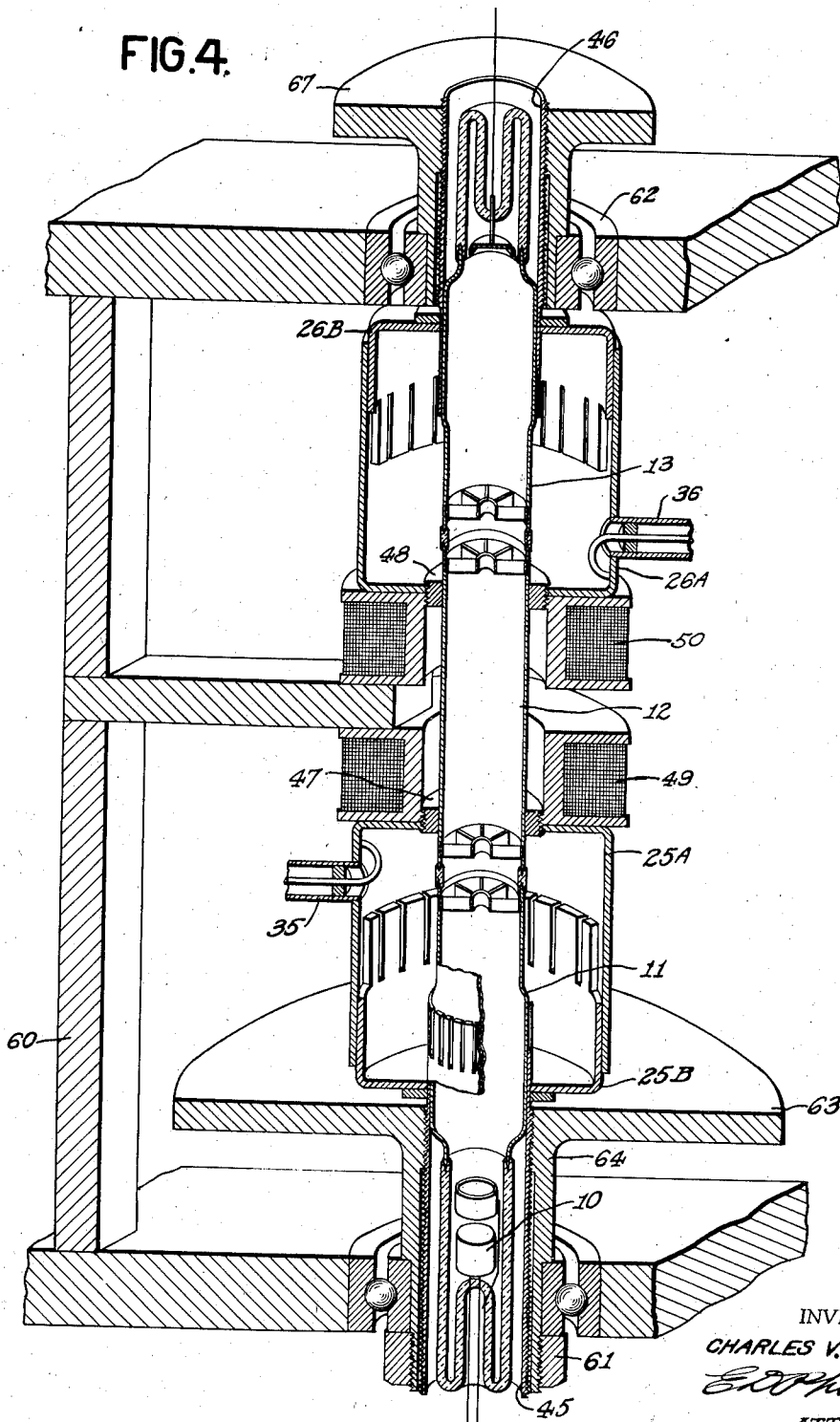
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2 Sheets-Sheet 2



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VELOCITY MODULATED TUBE WITH
REMOVABLE RESONATORCharles V. Litton, Redwood City, Calif., assignor
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2 Claims. (Cl. 250—27.5)

This invention relates to velocity modulated tubes and more particularly to velocity modulated tubes having readily removable closed cavity resonant circuits.

Vacuum tubes have been proposed using the variation in velocity of electrons in an electron beam to produce or amplify high frequency energy. In such tubes it has been proposed to use closed resonant chambers to effect the control of the electron velocity and to extract energy from the beam. These tubes, however, have a number of disadvantages. The space within the closed chamber is generally part of the tube envelope requiring a large volume to be evacuated. Further, if any fault develops in either resonant chamber the entire tube becomes faulty.

Moreover, the tuning of the circuits and the wave range of operation of the tube can only be adjusted over a small range limited by the size of the closed resonant circuits and the limited adjustment possible in these circuits.

It is an object of my invention to eliminate some or all of the difficulties outlined above.

It is a more specific object of my invention to provide a velocity modulated tube with removable closed resonant circuits, which can be readily replaced and need not be evacuated.

It is a further object of my invention to provide a velocity modulated vacuum tube in which the tuning range may be altered by replacing closed circuits tuned to a given frequency by other circuits tuned to a different frequency without destroying the vacuum within the tube.

It is a still further object of my invention to provide a tuning means for velocity modulated tubes by which the dimensions of external resonant chambers are adjusted to determine a desired resonant frequency.

A better understanding of my invention, as well as the objects and features thereof, may be had from the particular description of certain embodiments thereof made in connection with the accompanying drawings, in which—

Fig. 1 illustrates an embodiment of my invention;

Fig. 2 illustrates a modified form of my invention, and

Figs. 3 and 4 illustrate embodiments of my invention incorporating adjustable features.

In Fig. 1 is disclosed a form of velocity modulated electron beam tube. This tube includes an electron emitting cathode 10 which serves as an electron gun for producing an electron beam. The electrons emitted from cathode 10 may be accelerated by potentials applied to succeeding por-

tions of the tube. Cathode 10 is contained within an evacuated envelope comprising conductive tubular portions 11, 12, 13, sealed together at 14, 15 to provide a continuous tubular arrangement and sealed at one end by a glass press 16 and at the other end by a glass seal 17. In the end of tubular elements 11 and 12 adjacent one another are provided two discs 21, 22, in which openings are provided which serve to modify the velocity of the electron beam. In the opposite end of tube 12 and the adjacent end of tube 13 are provided two similar discs 23, 24 provided with similar control openings. If desired, these openings may be provided with a grid structure thereacross in order to distribute the potential more evenly across the openings. Overlying the tubular portion and in electrical contact with tubular elements 11 and 12, is a first resonant chamber 25. This resonant chamber is tuned to the desired operating frequency and serves to modify the velocity of electrons in the beam at the operating frequency as they pass between openings 21 and 22.

The electrons of the beam after passing grid 22 traverse tube 12 a distance sufficient to insure a bunching of the electrons. As the electron beam passes between the openings in discs 23, 24, energy is extracted from these loops by means of a second resonant chamber removably supported on the evacuated envelope and in electrical contact with tubular elements 12, 13. This second resonant chamber 26 is tuned to the operating frequency and serves to reduce the velocity of electrons in the stream, and extract energy therefrom at the frequency determined by chamber 25 and the grouping of the electrons within the tube. A target electrode 27 is provided for removing the electrons after passing discs 23 and 24 from the tube.

A concentric transmission line 35 having a coupling loop 37, is provided for introducing energy at the operating frequency into chamber 25, and a similar concentric line 36 and loop 38 is provided for extracting energy from resonant chamber 26. If the tube is to be used as an oscillator, energy may be fed back over lines 36 and 35. However, if the tube is to be used for amplification the input energy may be applied at 35 and the extracted energy obtained at line 36.

Since resonant chambers 25 and 26 are removably supported on the evacuated portion of the tube, it is clear that only a small volume need be evacuated. Furthermore, if it is desired to alter the frequency of operation of the system it is

merely necessary to provide in place of chambers 25 and 26, other chambers tuned to a different operating frequency. The resonant chambers 25, 26 are made with the inner tubular portion thereof resilient so that they will bear against the tubular portions of the evacuated envelope to make good electrical contact. Good operating characteristics may be achieved with a resonant ratio of 2:1, since the actual drift distance length is not critical. Furthermore, the variation in speed of the electron beam may be adjusted to in part compensate for the change in drift distance by adjusting accelerating potentials applied to the resonant chambers or to any accelerating electrode within the tube. When the tube is to be utilized at different operating frequencies as an oscillation generator, it is only necessary to properly adjust the phase of feedback energy in order to accommodate it to the different wavelengths thereof. Phase adjustment may be readily accomplished external of the circuit by means of a telescopic concentric line arrangement. Furthermore, since the resonators need not be evacuated, it is unnecessary to seal the concentric line members.

Fig. 2 illustrates another embodiment of my invention similar to that shown in Fig. 1. However, in this arrangement the evacuated envelope is made substantially wholly of glass as indicated at 40, the only metal portion of the envelope being shown as target electrode 17 sealed to the glass envelope. Within the glass envelope are provided tubular elements 11A, 12A, 13A, corresponding to 11, 12 and 13 of the structure of Fig. 1. These elements carry discs for the accelerating and extracting electrodes 21, 22, 23 and 24, respectively, which also correspond to the similar elements of Fig. 1. Two removable resonant circuits 25, 26 with concentric lines 35, 36 are adjusted on the tube external the glass envelope into a position to provide faster coupling between these chambers and elements 11A, 12A and 13A to provide the desired A. C. voltages for the grid openings in discs 21, 22, 23 and 24. Chambers 25 and 26 are preferably provided with slotted wall arrangements as indicated at 29 in chamber 26, so that the inner portions thereof will be spring pressed to hold firmly against the glass envelope 40. If it is desired to alter the frequency by substituting resonant cavities having a different tuning, chambers 25 and 26 may be removed and others resonant at different frequencies substituted in their stead. If it becomes necessary under these circumstances to alter the electron stream velocity, control of the stream may be effected by means of potential changes on accelerating electrode 41.

It will be clearly understood that a tube of this type may be readily used as an amplifier or an oscillator in the same manner described specifically in connection with Fig. 1.

It may be desirable to provide a tuning system so that the tuning of the operating potential of the tube may be varied over a wide tuning range without exchanging one resonant cavity for a different one. In Fig. 3 is illustrated a tube provided with removable resonant chambers which may be adjusted to alter the tuning of the tube with respect to the operating frequency.

In this arrangement the tube envelope may comprise the tubular elements 11, 12, 13, sealed together as in Fig. 1, and provided with grid supporting discs 21, 22, 23 and 24. Resonant

chambers 25, 26, each consist of two parts 25A, 25B, 26A, 26B, which are telescopically arranged together so that the operating frequency of the system may be readily adjusted. As previously stated this adjustment should not be greater than about a 2:1 ratio for proper operation of the tube. In this embodiment the target electrode 17 is sealed directly to one end of tubular member 13, instead of being mounted separately, as in Fig. 1. It should be distinctly understood that this adjustable tuning chamber arrangement may be readily applied to tubes of the type shown in Fig. 1 or Fig. 2. In view of the fact that the chambers 25, 26 do not need to be exhausted the slide connection for altering the tuning thereof is readily accomplished.

In Fig. 4 is shown a tube somewhat similar to Fig. 3 but showing more completely details for mounting the tube and adjusting the tuning of the circuit. In this figure the elements corresponding to elements of Fig. 3 are designated by similar reference characters. On each of portions 25B and 26B are provided additional tubular extensions 45, 46, provided with external threading. Likewise, two threaded discs 47, 48 are rigidly fastened to tube 12 and portions 25A and 26A, respectively, are held in place on these discs by threaded connections. These chamber portions 25A, 26A are locked in place on the nuts by means of the focusing coils shown at 49, 50, respectively, the supports of which are likewise threaded on discs 47, 48. The tube is mounted in an upright position by means of a supporting framework shown generally at 60. Rigidly fixed to supporting structure 60 are ball races 61, 62. A tuning disc 63 is mounted to rotate with the inner portion of the ball race 61. Disc 63 is provided with a sleeve 64 which is internally threaded to engage with the external threads on tubular element 45. Thus, as disc 63 is rotated element 25B is advanced or withdrawn from a telescopic engagement with part 25A, to adjust the tuning. Similarly, a threaded control element 67 is associated with the tubular portion 46 for advancing or withdrawing elements 26B from 26A to accomplish the adjustment of tuning.

While I have described my invention in connection with particular embodiments thereof, it is clear that these are made merely by way of illustration. Many other forms of the tube structure, as well as other adjusting means for adjusting the tuning will readily present themselves to those skilled in the art. What I consider my invention and desire to protect in my Letters Patent is embodied in the accompanying claims.

What is claimed is:

1. A vacuum tube comprising an evacuated envelope containing means for producing a beam of electrons of a given average velocity, velocity modulating electrodes in the path of said beam for modifying the velocity of electrons in said beam, drift means for allowing electrons in said beam to become grouped after modification of their velocity, and extracting electrodes for extracting energy from said grouped electrons, a first substantially closed resonant chamber removably mounted externally of said envelope coupled to said velocity modulating electrodes, a second substantially closed resonant chamber removably mounted externally of said envelope coupled to said energy extracting electrodes, each of said chambers comprising two telescopic sections adjustable for tuning said chambers, and

means for adjusting the relative positions of said sections to control the tuning.

2. A vacuum tube comprising an evacuated envelope containing means for producing a beam of electrons of a given average velocity, velocity modulating electrodes in the path of said beam for modifying the velocity of electrons in said beam, drift means for allowing electrons in said beam to become grouped after modification of their velocity, and extracting electrodes for extracting energy from said grouped electrons, a first substantially closed resonant chamber re-

movably mounted externally of said envelope coupled to said velocity modulating electrodes, and a second substantially closed resonant chamber removably mounted externally of said envelope coupled to said energy extracting electrodes, one of said chambers comprising two telescopic sections, a screw-threaded sleeve carrying one of said sections, and a rotatable disc cooperating with the screw threads axially to displace said sleeve for tuning the chamber.

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