

July 27, 1948.

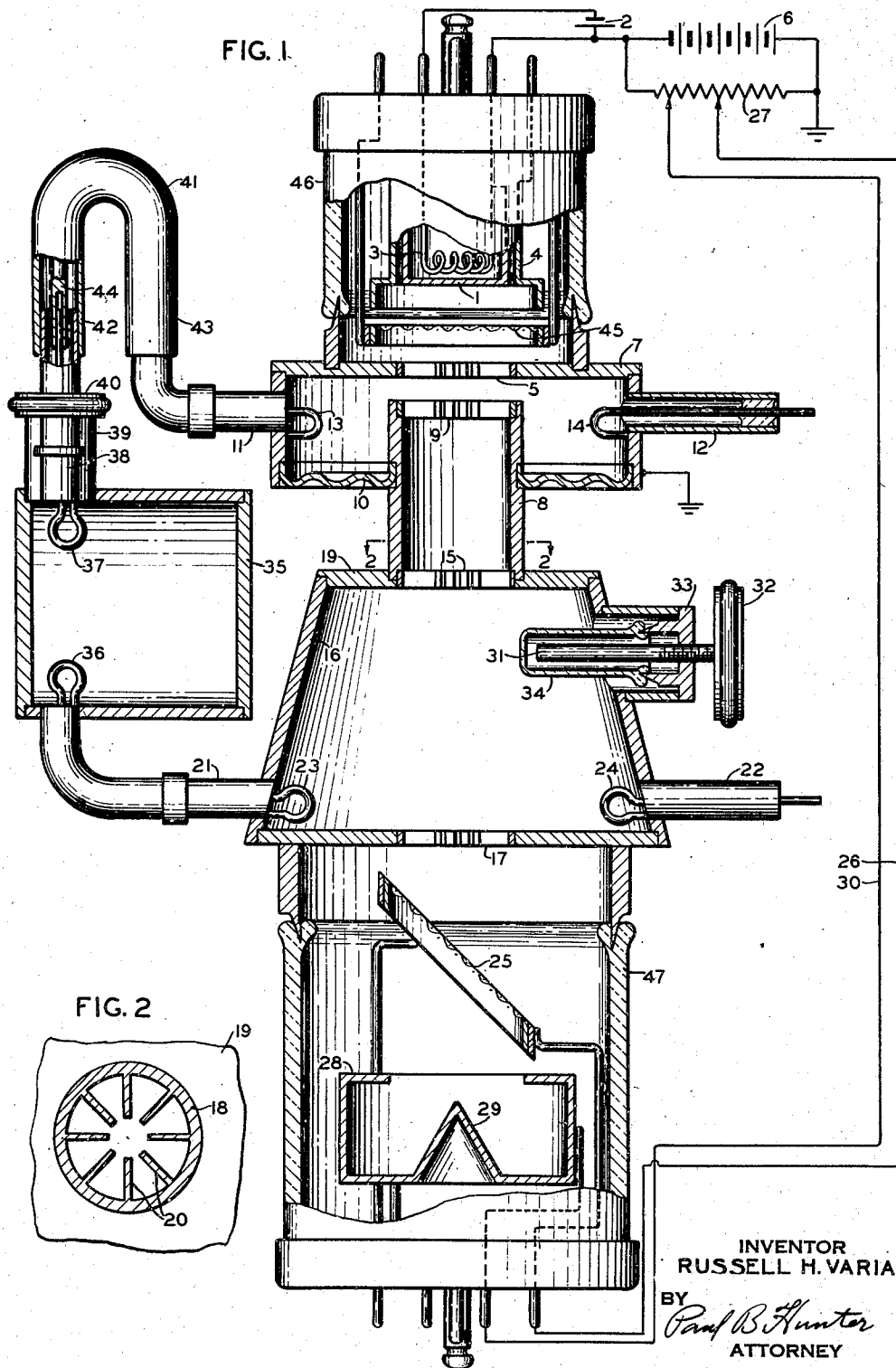
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HIGH FREQUENCY TUBE STRUCTURE

Filed Dec. 22, 1941

2 Sheets-Sheet 1



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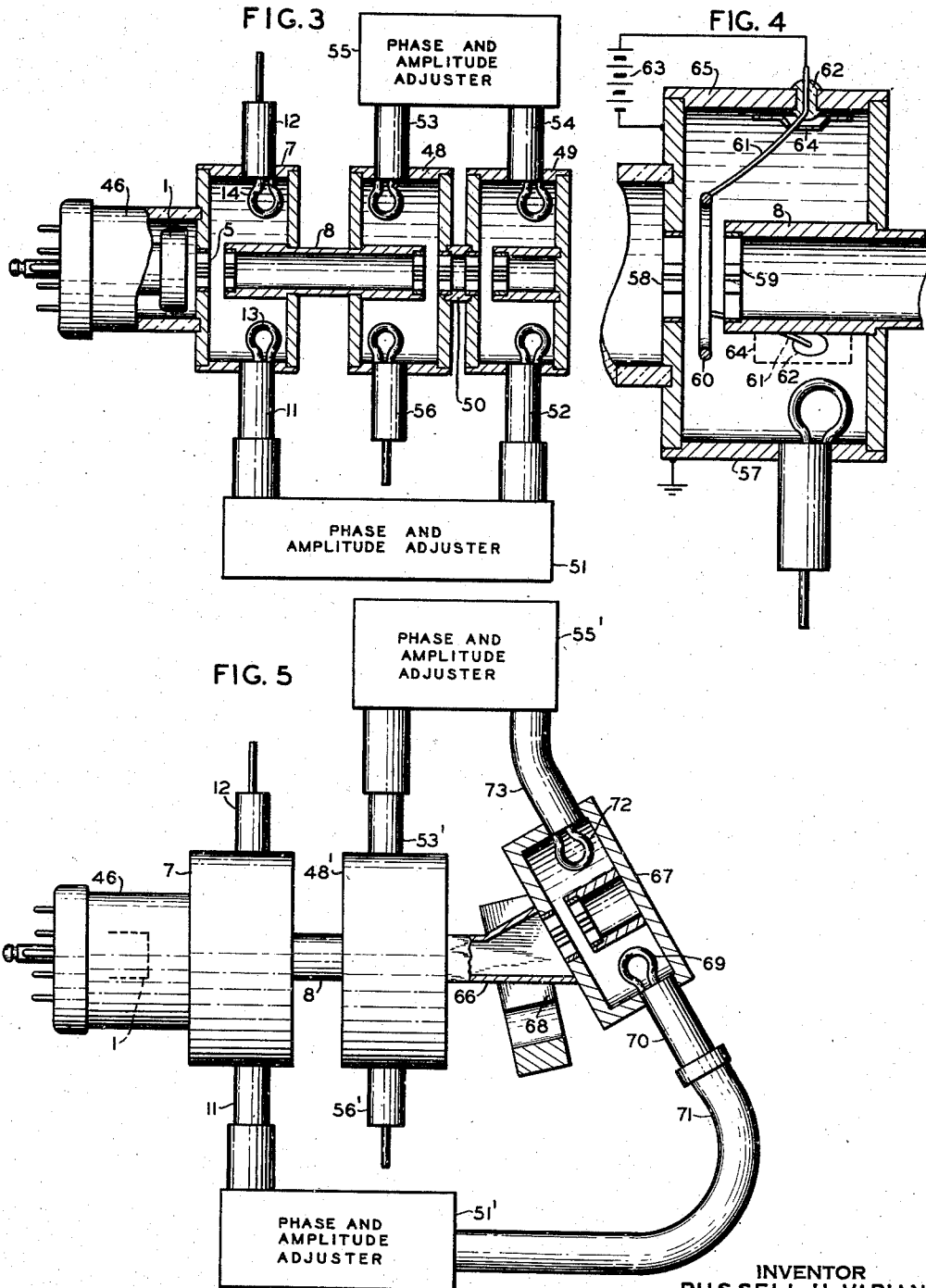
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2 Sheets-Sheet 2



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2,445,811

HIGH-FREQUENCY TUBE STRUCTURE

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25 Claims. (Cl. 315-6)

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This invention relates, generally, to ultra-high frequency apparatus operable at wavelengths of the order of one to one hundred centimeters and is more particularly concerned with modifications and improvements of electron beam tubes of the type disclosed in Patents No. 2,242,275, issued May 20, 1941, in the name of Russell H. Varian and No. 2,259,690, issued October 21, 1941, in the names of William W. Hansen, Russell H. Varian and John R. Woodyard, the purpose of said modifications and improvements being to increase the overall efficiency of such tubes. This application is a continuation-in-part of U. S. Patent No. 2,280,824, filed April 14, 1938, and issued April 28, 1942.

The devices of the above-mentioned disclosures are therein shown to consist of an electron beam arranged to traverse alternating electric fields of hollow resonant means, thereby causing velocity changes of the electrons and subsequent bunching thereof, to form a density-modulated beam, the bunches acting to maintain an oscillating ultra-high frequency field in the resonant means.

As shown in the aforementioned patents, and in the article entitled "Cathode-ray bunching" by David L. Webster, Journal of Applied Physics, vol. 10, page 501, July 1939, the theoretical maximum efficiency of such an electron beam velocity modulation device, when used as an oscillator, is 58 per cent. It is also therein shown that the density-modulated beam leaves the second resonator of the device while still maintaining its "bunched" characteristic and remains bunched for some distance after having left this second resonator. The devices of the present invention provide apparatus for the utilization of a portion of the unused energy of such "bunches" of electrons.

The principal object of the present invention is to provide a novel ultra high frequency tube structure of enhanced efficiency obtained as by effecting more complete bunching of the electrons of the electron stream used, by removal of energy dissipating secondary electrons, and by segregating faster electrons from the slower electrons after the stream has left the catcher resonator and abstracting further energy from the faster electrons.

One object of the present invention is to provide resonant cavity means for abstracting additional energy from the still more or less bunched electron beam leaving the final resonator of ultra-high frequency tubes of the above character.

Another object of the present invention is to

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effect bunching of the electron stream in two steps employing a "buncher" resonator to effect the main bunching of the stream and then passing the latter through an auxiliary "buncher," the formed bunches passing through the auxiliary "buncher" in such phase as to be substantially unaffected thereby while the electrons between the bunches are changed in velocity so as to consolidate with the formed bunches before entering the "catcher" resonator.

Still another object is to provide means operating on the electron beam after its passage through the second resonator to separate the electrons in accordance with their respective velocities and to abstract additional energy from the faster electrons.

A further object lies in the provision of amplitude and phase adjustment means in the feed back line between resonators.

Yet another object is to provide external highly resonant means for matching the natural frequencies of any two such resonant devices.

Another object is to provide electrode means for the removal of positive ions and secondary electrons from the space between the polar grids of such internally resonant electron beam devices.

Yet another object is to provide means for efficiently utilizing the direct current component of the electron beam velocity modulated by such electron beam velocity modulation devices by providing means for velocity modulating said unused direct current component.

Still another object is to provide resonant means for further sharpening the density modulated groups produced by a velocity modulating hollow cavity resonator so that enhanced conversion efficiencies result in a third hollow cavity resonator. Yet another object is to provide improved means for the collection of the electrons of an electron beam after the beam has yielded up its energy to utilization means.

A further object is to provide a tube structure having a hollow resonator for effecting partial bunching of the electrons of the stream and a second hollow resonator for effecting further bunching and energy absorption from the stream.

Other objects and advantages will become apparent from the specification, taken in connection with the accompanying drawings wherein the invention is embodied in concrete form.

In the drawings,

Fig. 1 is a partial cross-section elevation view of one form of the present invention.

Fig. 2 is a fragmentary detail taken along the line 2—2 of Fig. 1.

Fig. 3 is a partial elevation cross-section view of an alternate form of Fig. 1.

Fig. 4 is a fragmentary cross-section view showing a modified resonator form.

Fig. 5 is a partial cross-section elevation view of an alternate form of Fig. 3.

Similar characters of reference are used in all of the above figures to indicate corresponding parts.

Referring now to Fig. 1, an electron emitting surface 1 is shown heated by current passing from a battery 2 through a heater filament 3. Electrons from emitter 1 are focused by means of a focusing shield 4 and accelerated toward a grid 5 by means of voltage supplied by a battery 6. Grid 5 forms the entrance grid to a resonator 7 shown as of the reentrant type. The reentrant portion of resonator 7 is formed by a hollow conducting tube 8, which mounts a grid 9 adjacent to grid 5. One wall 10 of resonator 7 is made flexible, so that the resonant frequency of resonator 7 may be varied by changing the distance between grids 5, 9. Any suitable mechanical device may be used to cause flexure of said wall 10, such as described in Patent No. 2,242,249 issued to William W. Hansen and Sigurd F. Varian. Resonator 7 may be provided with coaxial line elements or terminal posts 11, 12, having inner coupling loops 13, 14, respectively, for the introduction into or the removal of high frequency energy from resonator 7.

Opposite to grid 9 on tube 8 is a grid 15, which forms the entrance grid of an internally resonant cavity resonator 16 of the type disclosed in co-pending United States Letters Patent No. 2,269,456 issued January 13, 1942. The resonator shape is preferably that of a frustum of a right circular cone, the grid 15 being centrally located in the top surface of said frustum. A grid 17 may be provided also, located centrally in the bottom of the cone. Grids 5, 9, 15 and 17 may be similar to the conventional type of grid shown in Fig. 2, consisting of ring 18 in an aperture in plate 19, radial grid bars 20 being attached to the inner periphery of said ring. In some instances, as when using high accelerating voltages, these grids may be omitted. Resonator 16 may be provided with concentric line elements or terminal posts 21, 22, terminated in resonator 16 by means of coupling loops 23, 24, respectively. It is to be understood that any of the types of resonators shown or described in the aforementioned Patent No. 2,269,456 may be substituted for the particular shape shown as resonator 16.

In use, electrons accelerated through grid 5 are acted upon by a high frequency electric field which may be assumed to exist between the grids 5 and 9. As described in the aforementioned Patent No. 2,242,275, such action causes recurrent velocity changes of the electrons of the stream; and, if entrance grid 15 is placed at an optimum distance from grid 9 such velocity changes result in recurrent grouping of the electrons in the vicinity of grid 15. Actually the beam at grid 15 has two current components, the bunches, which constitute an alternating current component, and electrons strung along between the bunches which constitute a direct current component. The bunches enter resonator 16 when the alternating field therein is weak so that these bunches are not materially affected, whereas the electrons intermediate the bunches enter when the field is relatively strong so that these electrons

are further consolidated with the bunches during the travel of the latter through the resonator 16. The condition that the bunches enter the resonator when the field is weak is that the field shall have a phase difference of 90 degrees with respect to the high frequency component of the electron current. The electrons of the direct-current component are alternately speeded up and slowed down while in resonator 16 as discussed in detail in Patent No. 2,269,456 to form bunches during their travel through resonator 16. The resulting bunches formed from the two current components travel in phase on toward grid 17, thence passing on through grid 17 during the low portion of their speed cycle.

Tuning of resonator 16 may be accomplished as by means of conducting plunger 31, which, by rotation of knob 32, cooperates with threads on collar 33, so that more or less of plunger 31 may be extended into the field inside resonator 16, thus distorting the lines of flux of said field and altering its natural oscillation frequency. Glass envelope 34 is provided over tuner slug 31 to provide continuity to the vacuum envelope of the device and end bell jars 46 and 47 also are for this purpose. If desired, only the path taken by the electron stream need be evacuated as by use of a vitreous tube surrounding the stream on tube sections within the resonators as disclosed in U. S. Letters Patent No. 2,280,824, issued April 28, 1942.

In order for the device to serve as an oscillator, properly phased feed-back should be provided between resonators 16 and 7. From resonator 16, energy coupled by means of loop 23 travels through concentric line 21 coupled into a hollow resonator device 35 by means of coupling loop 36. Another loop 37 is provided in resonator 35 and is formed on a concentric line element 38, which is rotatable in a collar 39 by means of a knob 40, thus causing loop 37 to cut more or fewer of the lines of flux of the oscillating electromagnetic field inside of resonator 35 and thereby adjusting the coupling between loops 36 and 37 accordingly. Attached to rotatable line 38 is a slidably mounted concentric line trombone section 41, whose outer and inner conductors 42 and 44 are adapted to slide over the conductors of line 38. The end 43 of line 41 is constructed in a similar manner, being slidably mounted over the conductors connected with concentric line post 11. Rotation of loop 37 then provides amplitude adjustment of the energy allowed to couple into resonator 7, thus providing optimum voltage between grids 5 and 9 of resonator 7. The position of trombone element 41 determines the phase with which resonator 7 is excited, so that the density-modulated beam of electrons may enter resonator 16 at the optimum time.

If resonator 35 is made very highly selective, tuning devices 10 and 31 may be omitted from broadly resonant devices 7 and 16, respectively, as resonator 35 will then determine the frequency of the system, provided resonators 7 and 16 are designed to operate at a frequency very close to that of resonator 35. In use as an oscillator, line 12 may be omitted, and high frequency power can be extracted from line 22. Grid 45, shown positioned between emitter 1 and entrance grid 5, when suitably excited, may be used to provide modulation, or may be used for control purposes, or may be omitted. In use as an amplifier, lines 11 and 21 and phase and amplitude adjusting devices 36 to 44, inclusive, may be omitted. The signal to be amplified is then introduced through

line post 12 and the amplified signal is removed through line post 22.

Electrons passing through exit grid 17 of resonator 16 may have a part of their energy returned through the leads 26 and 30 to battery 6 by means of electrodes 25 and 28. Electrode 25 is a mesh wire grid placed at a sufficient angle to the axis of the electron beams to prevent slow speed electrons reflected thereby from entering resonator 16. Also any secondary electrons produced when the beam strikes such grid are reflected away from resonator 16. Grid 25 is held at a fraction of the accelerating voltage supplied by battery 6. Electrons traveling toward grid 25 do work against the field between grids 17 and 25, thereby returning energy to battery 6. Electrons which succeed in passing through grid 25 due to their high velocity are slowed down by and are finally caught by an electrode 28, which functions as a Faraday cage and which is held at or very near the potential of cathode 1, the electrons doing work in the field between grid 25 and electrode 28. The reentrant centrally positioned cone 29 in electrode 28 acts to direct secondaries emitted when high velocity electrons strike its surface toward the outer cylindrical walls of electrode 28, thereby collecting such secondaries.

Fig. 3 discloses a device alternate to that shown in Fig. 1, the resonator 16 of Fig. 1 now being replaced by two resonators 48 and 49, connected by a very short drift tube 50. Resonator 48 may be provided with coaxial line elements or terminals 53 and 56, resonator 49 with similar terminals 52, 54. If the device is used as an oscillator, energy is coupled back from resonator 49 to resonator 48 through phase and amplitude adjusting means 55, which may be similar to devices 36 to 44, inclusive of Fig. 1, and from resonator 49 to resonator 7 by means of coaxial line elements 52 and 11 and phase and amplitude adjusting device 51; devices 51 and 55 being adjusted to secure optimum operating conditions.

Electrons from emitter 1 are accelerated by a driving voltage between emitter 1 and grid 5. In traversing resonator 7, the electrons of the beam suffer recurrent changes in velocity which action results in bunching as the beam passes through drift tube 8. The electron bunches are further bunched in resonator 48 by the action of the ultra high frequency electromagnetic field maintained therein, both by the beam and by energy fed back from resonator 49 through means 55. The electron groups leaving resonator 48 are therefore sharply bunched and resonator 49 absorbs energy from these bunches. The electron beam or stream entering resonator 48 also has a considerable direct current component, i. e., electrons intermediate the bunches. The oscillating field in resonator 48 tends to reduce such component by consolidating these electrons into the bunches, so that the resulting electron groups, appearing in resonator 49 in proper phase, release further energy therein. Energy may be removed to supply a load either from resonators 48 or 49, or both.

The device may be used as an amplifier if elements 51 and 55 are omitted, the signal to be amplified being introduced into resonator 7 through concentric line 12 and also through post 56 into 48, if desired, and the amplified signal removed from resonator 49 through line 52. It is evident to one skilled in the art that further energy could be extracted from the electron beam emerging from resonator 49 by allowing such

beam to pass through a fourth or a plurality of additional resonators, although difficulty may be experienced in arranging the geometry of the system so that useable voltages, phasing and amplitudes may be attained.

Secondary electrons emitted by grid structures on which high velocity beam electrons impinge, may become the source of considerable energy loss when such secondary electrons migrate at low velocities into the ultra high frequency fields existing between two grids of a resonant chamber, such as grids 5 and 9 of resonator 7 of Fig. 1. Fig. 4 discloses a device for removing such slow velocity-charged particles. Located centrally between grids 58 and 59 is a toroidal conducting member 60, coaxial with grids 58, 59 and supported by leads 61, passing through insulating vacuum tight seal 62 in the cylindrical wall 65 of resonator 57. Battery 63 charges torus 60 to a slight negative potential with respect to grids 58, 59, so that the charge on torus 60 then tends to repel all electrons from it, thus forcing slow moving electrons back into the electron stream and out of the space between grids 58, 59. Positive ions tend to be swept from said space by being attracted toward electrode 60. Electrode 60 also tends to have a slight amount of desirable electrostatic focusing action upon the beam providing slight focusing action to overcome radial defocusing due to mutual repulsion of the beam electrons. Electrode 60 is placed so that its capacity to grid 58 is equal to that to grid 59, and support leads 61 are likewise so placed that they link areas containing equal numbers of magnetic lines of flux. In order to return any ultra high frequency currents induced in elements 60, capacitative elements 64 are provided, which form by-pass condensers for the resonant frequency of resonator 57. Electrode 60 may also be placed so that the ratio of its capacities to grids 58 and 59 is the same as the ratio of the number of lines of magnetic flux linked on the respective sides of conductors 61. It is evident to one skilled in the art that this device may be used to improve the action of any hollow type resonator.

Fig. 5 shows a third modification of the present invention. As previously shown, an electron beam from emitter 1 is projected through resonator 7, wherein recurrent changes in velocity of the beam take place whereupon the beam travels on through drift tube 8 becoming gradually bunched or density modulated and enters resonator 48'. Thus resonator energy is released to generate and maintain an oscillating electromagnetic field as for supplying a load through terminal 56'. The electron groups after passing through resonator 48' contain electrons of differing velocities. A third resonator 67 is placed in the proximity of resonator 48'. A magnetic pole piece 68 is provided to velocity analyze the electron beam leaving resonator 48'. If resonator 67 is connected by drift tube 66 at a proper angle to the original beam axis of the device, the velocity analysis will allow only sharply pulsed electron groups to enter resonator 67 for driving this resonator. A portion of the energy of the field of resonator 67 may be returned through loop 69, concentric line elements 70 and 71, phase and amplitude adjusting device 51' and concentric line 11 to resonator 7, thereby maintaining an oscillating electromagnetic field of proper phase and amplitude in resonator 7 to effect bunching. Energy not needed for this purpose may be directed into resonator 48' by means of loop 72, line 73, phase and amplitude adjuster

55', and line 53'. If the device is used as an amplifier, elements 51' and 55' may be omitted, the signal being fed in at 12 and taken out both at 56' and 70.

As many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A high frequency tube structure comprising means for producing an electron stream, a hollow resonator positioned along the path of said stream in energy-exchanging relation thereto and adapted to produce bunching of the electrons of said stream, a second hollow resonator positioned along the path of said stream in energy-exchanging relation thereto and beyond said first resonator for producing further bunching of the electrons of said stream, a third hollow resonator positioned along the path of said stream in energy-exchanging relation thereto and beyond said second resonator for extracting energy from said bunched stream, and means coupling said third resonator to at least one of said first two resonators for feeding energy thereto.

2. A high frequency tube structure comprising means for producing an electron stream, means including a first hollow resonator positioned along the path of said stream and in energy-exchanging relation thereto for producing bunching of the electrons of said stream, means including a second hollow resonator positioned along the path of said stream in energy-exchanging relation thereto and beyond said first resonator for producing further bunching of said initially bunched electrons, means including a third resonator positioned along the path of said stream in energy-exchanging relation thereto and beyond said second resonator for extracting energy from said bunched electron stream, and means coupling said third resonator to said second resonator for feeding energy thereto.

3. A high frequency tube structure comprising means for producing an electron stream, means including a first hollow resonator positioned along the path of said stream in energy-exchanging relation thereto for producing bunching of the electrons of said stream, means including a second hollow resonator positioned along the path of said stream in energy-exchanging relation thereto and beyond said first resonator for producing further bunching of said bunched electron stream, means including a third resonator positioned along the path of said stream in energy-exchanging relation thereto and beyond said second resonator for extracting energy from said bunched electron stream, and means coupling said third resonator to said first resonator for feeding energy thereto.

4. A high frequency tube structure comprising means for producing an electron stream, means including a first hollow resonator positioned along the path of said stream in energy-exchanging relation thereto for producing bunching of the electrons of said stream, means including a second hollow resonator positioned along the path of said stream in energy-exchanging relation thereto and beyond said first resonator for producing further bunching of said bunched electron stream, means including a third hollow resonator positioned along the path of said stream in energy-exchang-

ing relation thereto and beyond said second resonator for extracting energy from said bunched electron stream, and means coupling said third resonator to both said first and second resonators for feeding energy thereto.

5. High frequency apparatus comprising means for producing an electron stream along a predetermined path, means along said path and adapted to interact with said stream for effecting recurrent partial bunching of electrons in said stream, means along said path and adapted to interact with said partially bunched stream for effecting further and sharper bunching of the electrons in said stream and for extracting energy from said further bunched stream, and means coupled to said last-named means for feeding some of said extracted energy back to said means for effecting partial bunching.

6. A high frequency tube structure comprising at least three hollow resonators mounted in tandem, said resonators being adapted to contain respectively spaced alternating electromagnetic fields, means aligned with said resonators for producing and passing an electron stream through said resonators in succession for successive energy exchanging interaction with said fields, and means coupling from the resonator through which said stream passes last to at least one of the two preceding resonators for feeding high frequency energy thereto.

7. A high frequency tube structure comprising a pair of spaced hollow resonators adapted to contain standing electromagnetic fields, means aligned with said resonators for projecting an electron stream along a predetermined path through said resonators in succession in energy-exchanging interaction with said fields, feed-back means coupling the second of said resonators through which said stream passes last to the first thereof for feeding high frequency energy from said second resonator to said first resonator, whereby a standing electromagnetic field is energized within said first resonator to effect recurrent changes in the velocity of the electrons of said stream, means along said path causing said velocity-changed electrons leaving said first resonator to become partially bunched by the time said electrons enter said second resonator, and means coupled to said second resonator for causing said second resonator to oscillate in a phase producing substantially no effect upon said partial bunches as they enter the standing field within said second resonator, whereby said electron bunches are substantially unaffected by said second resonator field while the electrons of said stream intermediate said bunches are consolidated with said bunches during their passage through said second resonator.

8. A high frequency tube structure comprising means for producing an electron stream, a hollow resonator positioned in the path of said stream for effecting recurrent velocity changes of the electrons of the stream, means in the path of said stream leaving said hollow resonator providing a drift space within which electrons of the stream become partially bunched, a second hollow resonator coupled with said drift space means for receiving the partially bunched stream and for effecting further and sharper bunching thereof, and a third hollow resonator connected with said second resonator on the side thereof away from said stream-producing means for receiving the bunched stream and for extracting energy therefrom.

9. A high frequency tube structure as defined

in claim 1 further comprising feedback connections coupling said third resonator to both said first and second resonators, said feedback connections having means providing phase and amplitude adjustments for the fed back energy.

10. High frequency apparatus comprising means for producing an electron stream along a predetermined path, resonant circuit means along said path for effecting recurrent changes in velocity of the electrons of said stream resulting in the consolidation of many of the electrons of said stream into successive bunches, further resonant circuit means along the path of said bunched stream for effecting consolidation of additional electrons of said stream with said bunches and for thereafter effecting absorption of energy from said more completely bunched stream, and energy feed-back means coupling said two resonant circuit means.

11. A high frequency tube structure comprising means for producing an electron stream along a predetermined path, means along said path, and including a first cavity resonator adapted to interact with said stream, for producing recurrent changes in the velocity of the electrons of said stream, means along said path providing a drift passage for said electrons to permit partial bunching thereof beyond said resonator, further resonator means along said path for receiving said partially bunched stream and for further consolidating electrons intermediate to said bunches with said bunches and for extracting energy from said consolidated and bunched stream, and means coupled to said further resonator means for supplying energy extracted from said bunched stream to said first resonator to maintain a standing electromagnetic field within said first resonator.

12. A high frequency tube structure as in claim 11, wherein said supplying means includes frequency stabilization and phase and amplitude control means.

13. High frequency apparatus comprising means for producing an electron stream along a predetermined path, means along said path for producing recurrent partial bunching of the electrons along said stream, means in said apparatus adapted to provide a high frequency alternating electromagnetic field, and means along said path for subjecting said bunched electrons to low intensities of said field and the electrons intermediate said bunches to high intensities of said field, whereby said intermediate electrons are consolidated with said bunched electrons to produce a higher degree of bunching.

14. High frequency apparatus comprising means for producing an electron stream along a predetermined path, resonant circuit means along said path and adapted to interact with said stream for producing recurrent variations of velocity of the electrons of said stream, means along said path defining an alternating-field-free space to effect partial bunching of said velocity-varied electrons, and second resonant circuit means along said path and adapted to interact with said partially bunched electron stream for producing further bunching of the unbunched electrons of said velocity-varied stream, said second bunching means comprising means for producing a standing electromagnetic field along the axis of said electron stream and having a phase producing a weak value of said field at the instant the bunches of electrons enter said field and a strong value at the instant that electrons intermediate said bunches enter said field, whereby the bunched

electrons are not materially affected, whereas the intermediate electrons are further consolidated with said bunched electrons.

15. High frequency apparatus comprising a pair of spaced hollow resonators adapted to contain standing electromagnetic fields, means for projecting an electron stream along a predetermined path successively through said resonators in energy-exchanging interaction with said fields, means coupled to the first of said resonators for energizing a standing electromagnetic field within said first resonator to effect recurrent changes in the velocity of the electrons of said stream, means along said path causing said velocity-changed electrons leaving said first resonator to become partially bunched by the time said electrons enter said second resonator, and means coupled to said second resonator for energizing said second resonator in a phase producing no effect upon said partial bunches as they enter the field of said second resonator, whereby said bunches are substantially unaffected by said second resonator field, while the electrons of said stream intermediate said bunches are consolidated with said bunches by action of said second resonator field.

16. High frequency apparatus comprising means for producing an electron stream along a predetermined path, means along said path for producing recurrent partial bunching of the electrons of said stream, and means in said apparatus adapted to provide a high frequency alternating electromagnetic field along said path phased to subject said bunched electrons to low intensities of said field and electrons intermediate said bunched electrons to high intensities of said field, whereby said intermediate electrons are substantially consolidated with said bunched electrons to produce a higher degree of bunching.

17. A high frequency tube structure comprising a hollow resonator having a pair of spaced grids between which an alternating electromagnetic field may be maintained, means for passing an electron stream in a selected path through said grids for interaction with said field, and an electron stream control electrode within such hollow resonator mounted to substantially surround said path between said grids.

18. High frequency apparatus comprising a substantially enclosed hollow cavity resonator adapted to contain an electromagnetic field, an electrode insulatingly supported within said resonator by means of supporting leads, said leads being disposed to link equal numbers of magnetic lines of flux of the electromagnetic field within said resonator.

19. High frequency apparatus as in claim 18, further including means for by-passing ultra high frequency currents induced in said supporting leads comprising capacitive elements forming by-pass condensers with the wall of said resonator.

20. High frequency apparatus comprising a pair of apertured conductive members, means providing an alternating electromagnetic field between said members, means for projecting an electron beam through said apertured members to traverse said field, and an electron beam control electrode mounted in the region of said field adjacent said members in operative relation to said beam during traversal through said field.

21. High frequency tube structure comprising a resonator for absorbing energy from a bunched electron stream, a second resonator spaced from said first-mentioned resonator, means for projecting an electron stream through said resonators, and velocity segregating means interposed

in the path of said electron stream between said resonators for selecting electrons of a desired velocity range for entering and driving said second resonator.

22. A high frequency tube structure as defined in claim 9 including means along the path of said electron stream in advance of said first-mentioned resonator for effecting bunching of the electron stream, and means coupled to one of said resonators and to said bunching means for returning energy from said one resonator to said bunching means for energizing the latter.

23. High frequency apparatus comprising means for producing a bunched electron stream, means for absorbing energy from said bunched electron stream, further means spaced along said stream from said first-mentioned absorbing means for absorbing energy from said electron stream, and velocity segregating means interposed between said energy absorbing means for permitting only electrons of a desired velocity range to enter said second energy absorbing means.

24. High frequency apparatus comprising means for producing an electron beam, means along the path of said beam for utilizing said electron beam, and means along said beam path for collecting said electron beam after utilization thereof, said collecting means comprising a grid structure disposed in the path of said beam in a plane at an acute angle with respect to the direction of said beam, whereby the electrons of said beam are prevented from being reflected into said utilization means and whereby secondary electrons derived from impinging of said beam on said grid are also prevented from affecting said utilization means.

25. High frequency apparatus comprising means for producing an electron beam, means along the path of the beam for utilizing said electron beam, and means along said beam path for collecting the electrons of said beam after the utilization thereof, said last means comprising a partially enclosed chamber adapted to receive said electrons and having a conical portion coaxial with the direction of said beam for preventing reflection of electrons or projection of secondary electrons back into said utilization means.

RUSSELL H. VARIAN.

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