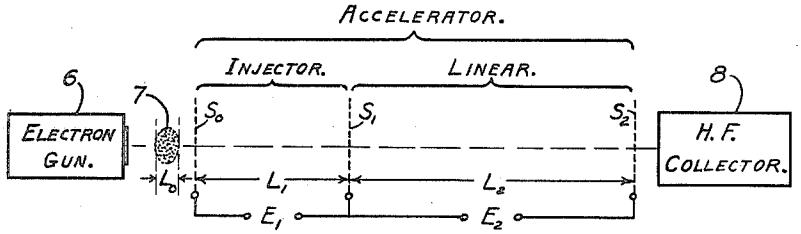
Feb. 9, 1943. H. M. STROBEL 2,310,815

ACCELERATION HIGH FREQUENCY GENERATOR

Filed Dec. 31, 1940



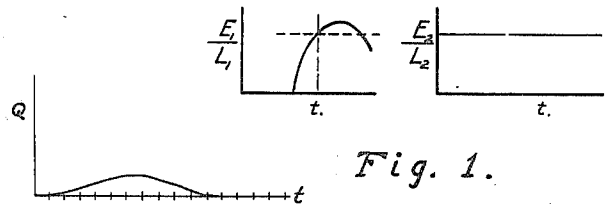


Fig. 1.

Fig 1A

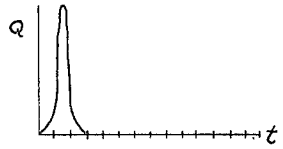


Fig 1B

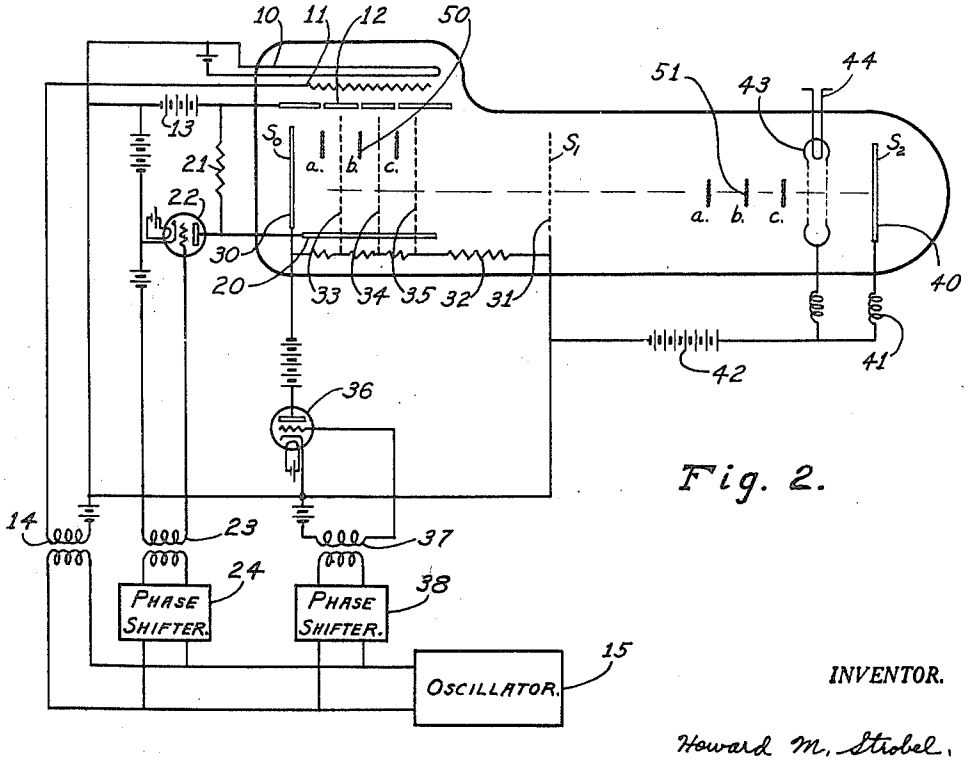


Fig. 2.

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2,310,815

ACCELERATION HIGH FREQUENCY GENERATOR

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Application December 31, 1940, Serial No. 372,562

26 Claims. (Cl. 250—36)

This invention relates to a high-frequency generating system of the type which is impulsed by successive groups of charged particles moving through space, and in which a given control frequency may be used to form the moving groups of charged particles in such a manner as to permit their use in generating frequencies greater than the given control frequency.

The object of the invention is to increase the velocity of groups of charged particles in such a manner as to retain the original space dimensions given to the groups during the process of formation.

The conventional type of electronic tube having the basic structure of filament, grid, and plate, or modifications thereof, is limited as to the highest frequency that it can generate by the time of transit of electrons from filament to plate. This time of transit can be reduced by reducing the physical dimensions of the tube elements, but such a procedure also limits the power output of the tube. These and other restrictions imposed by the conventional electron tube have indicated the need for new methods wherein the ultimate frequency obtainable was not limited by the minimum dimensions of the tube.

If a given control frequency is used to interrupt a stream of moving charged particles, successive moving groups of charged particles will result. These groups will have some given space dimension of length in the direction of motion which is determined by the velocity of the charged particles and the period of the controlling pulses of the interrupting frequency. The time interval that it takes for the group to pass a given point depends upon its space dimensions as to length and its given velocity, which is equivalent to the period or time interval or formation. If there is no change in either the length or velocity of the group, and the moving group is used to impulse an oscillating circuit, no increase in frequency will result, since the time interval of collection will be the same as the time interval of formation. To increase the frequency generated by the group impulses, it is necessary to decrease the time interval of collection. This can be effected in one of two ways, either by holding the velocity of the group constant and decreasing its space dimensions of length, or by holding the space dimensions of length constant and increasing the velocity of the group. Means for generating high frequencies by the former method have been disclosed in my patent application, Serial No. 372,563, filed December 31, 1940, patented July 7, 1942, Patent No. 2,289,319, while disclosing means for generating high frequencies by the latter method is the primary object of this application.

It is the further object of the invention herein disclosed to provide means and methods for increasing the velocity of a group of charged particles without increasing its space dimensions of length in the direction of motion, whereby the time interval of collection for the group can be made less than its time interval of formation.

The method of increasing the velocity of a group of charged particles (say, electrons) without altering the space dimensions of the group consists of means for avoiding entrance distortion to the electron group as it enters the region where it is to be accelerated by an electro-static field. If just one accelerating region is used, this can be effected by maintaining the region at zero field while the electron group is entering the region, and then applying the accelerating action of the field. This results in applying the accelerating action of the field simultaneously to all the particles in the group, so that each particle is increased in velocity by the same amount. If collection of the group is made while it is still in the accelerating field, or the accelerating electro-static field is reduced to zero before any substantial part of the electron group emerges from the accelerating region, the electron group will still retain its original space dimensions while it will be moving at an increased velocity. It follows that the time interval of collection is reduced, thereby favoring the generation of high frequencies.

Two accelerating fields used in cascade can be employed with certain advantages. In this method, the first region may be termed the "injector region" of the accelerator, and the second region termed the "linear region" of the accelerator. The magnitude of the electro-static field applied to the injector region is so controlled as to vary as some function of the time, while the magnitude of the electro-static field applied to the linear region is preferably a constant. That is to say, the voltage gradient (volts per unit length) in the injector region is some function of the time, while the voltage gradient in the linear region is a constant. With this arrangement, the electron group enters the injector region while the voltage gradient is equal to the zero value of the preceding region, and then the voltage gradient of the injector region is increased until it equals the voltage gradient in the following linear region of the accelerator. Under these conditions, the electron group passes from the injector region into the linear region while both regions have substantially the same voltage gradient, and hence there is no entrance distortion of the space dimensions of the electron group when it is thus "injected" into the linear region.

It is to be observed that if an electron group of given length were passed from a region of lesser or zero field directly into the linear re-

gion of some constant field, that entrance distortion of the space dimensions of the group would result. This is because the front electrons of the group enter the field first and are immediately accelerated by the electro-static field to a greater velocity than the rear electrons of the group. When the rear electrons of the group enter the linear region some time interval later, the front electrons, due to having been in the accelerating field longer, will have the greater velocity. After the whole of the group is in the linear field, the accelerating effects are the same on all electrons, both front and rear, so no further distortion is introduced. However, the effect of the entrance distortion, which gives the front electrons of the group a greater velocity than the rear ones, is to have the front and higher velocity electrons pull away from the slower rear electrons, so that the length or space dimensions in length of the group of electrons is increased with time. The longer the linear region, the more time it takes the group to traverse it, and hence the greater the increase in length of the electron group. If the electron group then emerges from the field of the linear region into a region of zero field, emergence distortion will take place, which is the reverse of entrance distortion and tends to cancel the velocity differences so that all electrons of the group are then moving at the same velocity, except that the emergence velocity is greater than the original entrance velocity. It is to be noted that the emerging electron group is moving at a higher velocity, but that due to the distortion introduced, the space dimensions of length of the group have been increased proportionately. As a result, the increased velocity and the increased length of the electron group nullify one another, so that the time interval of collection is the same as it was before the acceleration took place. It is to avoid this null effect that some means for preventing distortion of the type described is necessary.

More particularly, the invention consists in the system and method hereinafter described, illustrated in the accompanying drawing and defined in the claims hereto appended, it being understood that various changes in form, arrangement and details both of circuits and of method within the scope of the claims may be resorted to without departing from the spirit or sacrificing any of the advantages of the invention.

A clearer understanding of the operation of the invention and its improvement over known methods can be obtained by reference to the following figures and the descriptions relating thereto.

Figure 1 shows in brief outline the positions of the accelerator regions, as well as graphic representation of the voltage gradients applied to each region. The graphs Fig. 1A and Fig. 1B show graphically the distribution of charge with time of a group of charged particles before and after acceleration.

Figure 2 shows a high-frequency generator tube with a circuit diagram of one means for operating the tube.

Figure 1 shows in a graphic manner the accelerator regions and relationships of associated equipment. The accelerator region includes the space between the screens S_0 and S_2, which in turn is composed of two component regions, one being designated "injector" and being between screens S_0 and S_1, and the other being designated "linear" and being between screens S_1 and S_2. The length of the injector region is indicated by the letter L_1, while the length of the linear region is indicated by the letter L_2. The voltage functions applied between the screens of the respective regions are indicated by E_1 and E_2 as shown. Graphic representation of how the voltage gradient (voltage per unit length, or E/L) for each region varies as a function of the time is shown by the graphs below the respective regions. In the graphs, the voltage gradient E/L is plotted against time t; as a result, the form of the curves also show how the voltage functions E_1 and E_2 vary with time t. The block 6 indicates an electron gun so controlled and positioned as to be able to form moving groups of electrons 7 which pass through the screen S_0 into the injector region. The length of the electron group 7 is designated by L_0. Lock 8 indicates a high-frequency collector or oscillating circuit which is impulsed by the high velocity electron groups generated by the accelerator.

The principle of operation of the accelerator high-frequency generator may be explained by reference to Figure 1. The electron gun 6 forms a moving group of electrons 7 having the space dimension with regard to length of L_0. The direction of motion of the electron group 7 is such as to cause it to pass through the screen S_0 into the injector region. The period of time that it takes the electron group 7 to pass through the screen S_0 with its original velocity V_0 may be designated as T_0. The value of T_0, of course, will vary directly with L_0 and inversely with V_0. During the period T_0 that the electron group 7 is entering the injector region, there is no voltage applied to the terminals of E_1 between the screens S_0 and S_1, so that zero field exists therein. That is, during the time interval of passage through a boundary surface, the fields of the regions so defined are equal. After the electron group 7 is wholly within the injector region, an electrostatic field is created therein by the applied voltage function E_1. The instantaneous voltage of the voltage function E_1 creates a given voltage gradient E_1/L_1 in the injector region, which simultaneously accelerates all the electrons in the electron group, thus increasing their velocity towards screen S_1 while the electron group length L_0 remains unchanged.

The voltage applied across the screens S_1 and S_2 is shown as a constant E_2, which gives a constant voltage gradient E_2/L_2 with time t as is shown by the graph below the linear region. By a proper choice of the voltage function E_1 applied to the injector region, it is possible to have the voltage gradient E_1/L_1 just equal to the voltage gradient E_2/L_2 during the time interval that the electron group is passing through screen S_1 from the injector region to the linear region. When the voltage gradient is the same in both regions for the time interval of passage through S_1 no entrance distortion of the length L_0 of the electron group will occur. Assuming a sinusoidal form of voltage gradient E_1/L_1 plotted against time t as shown in the graph, there will be two points where the dotted line value equal to E_2/L_2 of the linear region will intersect the curve. By proper timing and control of magnitude, either of these points can be used for the time interval of passage of the group through the screen S_1. It is to be observed, of course, that by reducing the magnitude of the E_1/L_1 function, that the intersection of the curve and the dotted line would occur at the peak of the

curve, which would produce a longer time interval during which the two regions were at substantially the same voltage gradient. It is also to be noted, that since the electron group has been accelerated and consequently increased in velocity without increase in its length L_0, that the time interval for passing through screen S_1 will be proportionately less than the time interval T_0 originally required for passage through screen S_0.

Once the electron group is in the linear region, it will be further increased in velocity without change in its space dimensions, until it passes through the screen S_2. On passing from the linear region of constant field to the region of zero field beyond, emergence distortion will tend to alter the space dimensions of the electron group. This emergence distortion results from the fact that the front electrons of the group pass through the screen S_2 first into the following region of zero field and so are no longer being accelerated as are the rear electrons of the group which are still in the linear field. Hence, the rear electrons will be accelerated during the time interval that it takes the group to pass through the screen S_2, and as a result they will emerge with a velocity slightly greater than the velocity of the front electrons of the group. Emergence distortion of this type, however, is not objectionable, since it is of the kind that causes the rear electrons to overtake the front electrons, and so operates to decrease the length L_0 of the electron group up to the point where the rear electrons are even with the front electrons. Beyond this point, of course, the faster electrons will tend to draw away from the original front electrons, thereby tending to increase the length of the group. However, since the time interval of emergence is small, due to the high velocity of the accelerated electron group, and since the electron group can be collected at any position in space where its length is less than L_0, the emergence distortion is not of the objectional kind. In the event that it might be desired to prevent emergence distortion, it is obvious that an "ejector region" operating in an order the reverse of the injector region could be employed.

The graphs Fig. 1A and Fig. 1B show the charge distribution Q of a group of charged particles plotted against a time axis t, both graphs being to the same scale as regards Q and t. The graph Fig. 1A is representative of the charge distribution Q of the group 7 shown in Fig. 1. After the group has emerged from the accelerator and has had its velocity increased without changing its space dimensions of length, a graph of its charge distribution Q against time t will be substantially as shown in Fig. 1B. A comparison between the two graphs makes readily apparent that the emerging group can be collected in a smaller time interval than the entering group, and hence is capable of generating higher frequencies.

Entrance and emergence distortion of the space dimensions of an electron group can be illustrated by considering the effect of passing an electron group from a region of zero field to a linear region of constant field and then to another region of zero field. By omitting the injector region, reference can be made to Figure 1. Entrance distortion would occur due to the fact that the front electrons of the group would be undergoing an acceleration during the time interval of entrance of the group, and hence would have a velocity greater than the rear electrons of the group. Once the group was wholly within the linear region, all electrons of the group would be equally accelerated. However, since the front electrons still retain the greater velocity added to them by the entrance distortion, the front electrons will tend to pull away from the rear electrons, so that the length of the electron group will increase as time goes on. If collection of the electron group is made in the linear region, the time interval of collection will be the same as the original time interval of formation, for although the velocity of the group has been increased, so has the length of the group, so that the time interval of collection remains the same. The effect of emergence distortion is the reverse of the above, and is such that on finally emerging from the linear region into another following region of zero field the velocity of all electrons in the group is the same. The overall effect of the above operations, then, is to increase the length of the electron group in direct proportion as the velocity is increased, so that no decrease in the time interval of collection results. It is to overcome these null results that the method employed in the accelerator injector region is proposed.

When we consider the effect of passing an electron group of given space dimensions from one region to another through a dividing boundary plane, three cases arise as to possible distortion effects. The conditions associated with the three cases are: case one, where the field intensity in the first region is less than the field intensity in the second region; case two, where the field intensity in the first region equals the field intensity in the second region; and case three, where the field intensity in the first region is greater than the field intensity in the second region. Considering the passage of the electron group from a preceding first region into a following second region, no entrance distortion occurs in case two, but it does occur in cases one and three. Assuming fields of similar polarity and of such sense as to accelerate the moving electron group, the entrance distortion in case one will leave the front electrons with a greater velocity than the rear electrons of the group, while the entrance distortion in case three will leave the front electrons with a lesser velocity than the rear electrons of the group. The effect of case one will be to cause the electron group to increase in length as its velocity increases. The effect of case three will be to cause the electron group first to decrease in length as the faster moving rear electrons overtake the front electrons, and then to increase in length as the faster electrons pull away from the slower electrons of the group. In the above discussion of the three cases possible, it has been assumed that all the electrons in the group had the same velocity while in the first region.

With particular reference to Figure 1, the electron group passes through the boundary screen S_0 under conditions of case two, where both first and second regions have fields of equal electrostatic intensity (i. e., zero value). After the electron group is wholly within the injector region, the field strength can be increased to any desired value by a proper choice of voltage function E_1, so that with respect to the boundary screen S_1 between the injector and linear regions, either case one, two, or three can be made to apply. As mentioned previously, the non-distortion case two is preferred here. With respect to

the electron group passing through the boundary screen S_2, case three applies.

In general, when an electron group passes a boundary surface between two regions, the space dimensions of the group dictate that there must be some time interval or period of passage, since the elements of the group pass the surface single file. When the field strength is changed after the group is wholly within a region, however, the same effect is obtained as if all the electrons of the group passed simultaneously at the same instant into the new field.

Figure 2 shows an application of apparatus for making a high-frequency generator according to the method disclosed above. The electron gun includes the filament **10**, grid **11**, and plate **12**. The plate **12** contains a number of spaced narrow slits for extruding electron groups, such as those at **50** *a*, *b*, and *c*. The plate circuit of the electron gun is maintained at a positive potential by some energizing source, as the battery **13**. The grid **11** is energized by the coupling transformer **14** which in turn is energized by the oscillator **15**. The grid **11** maybe biased to cut-off by a grid battery included in the grid circuit as shown. The electron groups **50***abc* extruded from the electron gun plate **12** may have their downward motion cancelled by applying a cancelling field between the plate **12** and the cancelling plate **20**. The desired cancelling voltage is obtained by having a tube **22** pass a current through the dropping resistor **21**, while the tube **22** has its grid controlled as to magnitude and phase by the grid coupling transformer **23** and the phase shifter **24**. The phase shifter is energized by the oscillator **15**. After bringing the electron groups **50***abc* to a halt in the injector region between the screens **30** (S_0) and **31** (S_1), an accelerating voltage is applied between the screens **30** and **31** by generating a voltage drop across the dropping resistor **32**. Current is passed through the resistor **32** by a tube **36**, which in turn is controlled through the grid coupling transformer **37** and the phase shifter **38**. The phase shifter **38** is energized by the oscillator **15**. In order to maintain the field applied to the injector region uniform and to avoid field distortion due to fringe effects, equipotential screens or grids such as **33**, **34**, and **35** may be connected to points of proper potential on the dropping resistor **32**. After the electron groups **50***abc* pass from the accelerator injector region through screen **31** (S_1) into the linear region between **31** and **40**, they are further accelerated by the linear field of constant strength maintained by the battery or energizing source **42**. As shown in the diagram, the high velocity electron groups **51***abc* are about to pass through the collector or oscillating circuit **43**. The oscillating circuit **43** is shown as of the toroid form, and means for transferring high-frequency energy therefrom is indicated at **44**. Passage of high-frequency currents to the battery circuits may be blocked by the use of choke coils, as shown at **41**.

In operation, the electron gun extrudes the electron groups **50***abc* from the slits in the plate **12**, the electron groups **50***abc* moving downward into the injector region at a low velocity. A cancelling field of proper magnitude is developed between the plate **20** and electron gun plate **12** so as to decrease or cancel the downward edgewise velocity of the electron groups. The accelerating field then developed in the injector region between plate **30** and screen **31** then accelerates the electron groups simultaneously towards the screen **31**. During the time interval that the electron groups **50***abc* are passing through the screen **31** (S_1), the voltage gradient of the injector region is controlled so as to be equal to the voltage gradient of the linear region, thus preventing entrance distortion of the space dimensions of the electron groups. On entering the linear region, the velocity of the groups are still further increased without change in their space dimensions, so that when finally collected by the high-frequency oscillating circuit **43** the time interval of collection for each group is smaller than the original time interval of formation.

The above application of the invention serves to illustrate the method, but it is understood that variations may be introduced without departing from the spirit of the invention. For example, in Figure 2 the electron groups formed enter the injector region from the side, but could be introduced from the end similar to the manner diagrammed in Figure 1. The sidewise or lateral introduction of the flat-sided electron groups into the injector region permits the use of sharply defined electron groups which are favorable to high-frequency generation. Also, it will be obvious that the linear region could be omitted, so that all of the acceleration of the electron groups occurs in the injector region alone. In this case, of course, the voltage energizing source for the injector region would have to be capable of handling higher voltages if the same final velocity were to result. The advantage of the combination accelerator injector and linear regions is that most of the velocity increase can take place in the linear region which may be energized by a constant voltage, so that the variable voltage function applied to the injector region need be only of relatively low voltage.

In the event that the groups of charged particles are directed laterally into the side of the accelerator region at a low velocity, as is shown in Figure 2, it is not necessary that the lateral low velocity be totally cancelled. If the action of the accelerator increases the velocity along the tube to say 100 times the lateral low velocity, the lateral velocity would have a negligible effect upon the operation of the generator.

I claim:

1. In a high-frequency generating system utilizing high velocity charged particles in an evacuated vessel and including at least two electrode members spaced along a given path to form consecutive regions, the method of high-frequency generation which includes the steps of: forming a group of charged particles having a given space dimension of length; directing said group along said given path; creating an electrostatic field in any of said regions by controlling the voltage applied to the electrode members defining said region, said field being controlled with respect to the passage of said group through said region, so that during the time interval of passage of said group into said region said field is at most substantially equal to the field in the preceding region, and so that during the time interval of passage of said group from said region said field is at least substantially equal to the field in the following region, and so that any change in the strength of said field takes place during other time intervals such that an equal effect is produced simultaneously upon all the charged particles in said group; and collecting energy from said accelerated group of moving charged particles; whereby the velocity of said group is increased without increasing its space dimension

of length and the collector circuit is energized by a high-frequency impulse.

2. In a high-frequency generating system utilizing high velocity charged particles in an evacuated vessel and including at least two electrode members spaced along a given path to form consecutive regions, the method of high-frequency generation which includes the steps of: forming groups of charged particles having space dimensions of given length; directing said groups successively along said given path; creating an electrostatic field in any of said regions by controlling the voltage applied to the electrode members defining said region, said field being controlled with respect to the passage of said groups through said region, so that during the time interval of passage of said groups into said region said field is at most substantially equal to the field in the preceding region, and so that during the time interval of passage of said groups from said region said field is at least substantially equal to the field in the following region, and so that any change in the strength of said field takes place during other time intervals such that an equal effect is produced simultaneously upon all the charged particles in said groups; and collecting energy from said accelerated groups of moving charged particles; whereby the velocity of said groups is increased without increasing their space dimensions of length and the collector circuit is energized by high-frequency impulses.

3. In a high-frequency generating system utilizing high velocity charged particles in an evacuated region, the method of high-frequency generation which includes the steps of: forming a moving group of charged particles having a given space dimension of length in the direction of motion; passing said group of charged particles into an accelerator region during a time interval when the electrostatic field in said accelerator region is zero; creating an electrostatic field in said accelerator region of such sense as to simultaneously accelerate in the direction of motion all the particles of said group, thereby increasing the velocity of said group without increasing its length; and collecting energy from said accelerated group of moving charged particles, whereby the collector circuit is energized by a high-frequency impulse.

4. In a high-frequency generating system utilizing high velocity charged particles in an evacuated region, the method of high-frequency generation which includes the steps of: forming a moving group of charged particles having a given space dimension of length in the direction of motion; passing said group of charged particles into an accelerator region energized by a variable electrostatic field during a time interval when the electrostatic field in said accelerator region is zero; increasing the electrostatic field of said variable field region after said group is wholly within said variable field region, said variable electrostatic field being of such sense as to accelerate said group in its direction of motion; passing said accelerated group of charged particles into an accelerator region having a constant electrostatic field during a time interval when the field of the variable field region is at least equal to the field in the constant field region; and collecting energy from said accelerated group of moving charged particles; whereby the velocity of said group is increased without increasing its space dimensions of length and the collector circuit is energized by a high-frequency impulse.

5. In a high-frequency generating system utilizing high velocity charged particles in an evacuated region, the method of high-frequency generation which includes the steps of: forming charged particles of equal given velocity into a given space patterned group having a given space dimension of length in the direction of motion; passing said group into a field free region and then applying an accelerating electrostatic field equally and simultaneously to all the charged particles of said group, thereby increasing the velocity of the group without increasing its length and without changing its given space pattern; and collecting energy from said accelerated group of moving charged particles, whereby the collector circuit is energized by a high-frequency impulse.

6. In a high-frequency generating system utilizing high velocity charged particles in an evacuated region, the method of high-frequency generation which includes the steps of: forming charged particles of equal given velocity into substantially parallel flat-sided groups; passing said groups into a field free region and then applying an accelerating field equally and simultaneously to all of said groups of charged particles, said accelerating field being substantially perpendicular to the planes of minimum thickness of said flat-sided groups, thereby increasing the velocity of the groups without increasing their space length in the direction of accelerated motion; and collecting energy from said accelerated groups of moving charged particles, whereby the collector circuit is energized by high-frequency impulses.

7. In a high-frequency generating system utilizing high velocity charged particles in an evacuated region, the method of high-frequency generation which includes the steps of: forming charged particles of equal given velocity into a given space patterned group having a given space dimension of length in the direction of motion; passing said group into a field free region and then applying an accelerating field equally and simultaneously to all the charged particles of the group, thereby increasing the velocity of the group without increasing its length; passing said accelerated group into a region of constant field, thereby further increasing its velocity; and collecting energy from said accelerated group of moving charged particles, whereby the collector circuit is energized by a high-frequency impulse.

8. In a high-frequency generating system utilizing high velocity charged particles in an evacuated region, the method of high-frequency generation which includes the steps of: forming flat-sided groups of charged particles in substantially parallel planes; applying an accelerating field simultaneously to all the groups of charged particles, said accelerating field being substantially perpendicular to the planes of minimum thickness of the flat-sided groups, thereby increasing the velocity of the groups without increasing their space length in the direction of accelerated motion; passing said accelerated groups into a region of constant field, during a time interval when said accelerating field is at least substantially equal to the said constant field in intensity, thereby further increasing their velocity; and collecting energy from said accelerated groups of moving charged particles, whereby the collector circuit is energized by high-frequency impulses.

9. In a high-frequency generating system utilizing high velocity charged particles in an

evacuated region, the method of high-frequency generation which includes the steps of: forming a low velocity group of charged particles having a minimum dimension of length at right angles to the direction of motion; passing said group of charged particles laterally into an accelerator region of variable electrostatic field during a time interval when said variable field is zero; applying a cancelling field to said low velocity group of such magnitude and duration as to at least reduce the velocity of the group; increasing the field of said variable field region after said group is wholly within said variable field region, thereby accelerating said group in a direction substantially normal to the plane of minimum thickness of said group; and collecting energy from said accelerated group of moving charged particles; whereby the velocity of said group is increased without increasing its length in the direction of final motion, and the collector circuit is energized by a high-frequency impulse.

10. In a high-frequency generating syetem utilizing high velocity charged particles in an evacuated region, the method of high-frequency generation which includes the steps of: forming low velocity groups of charged particles simultaneously in parallel planes, said groups having a minimum dimension of thickness at right angles to their direction of motion; passing said groups of charged particles laterally into an accelerator region of controlled variable electrostatic field during a time interval when said field is substantially zero; applying a retarding field to said low velocity groups of such magnitude and duration as to at least reduce the given velocity of the groups; increasing the field of said variable field region after said groups are wholly within said variable field region, thereby accelerating said groups in a direction substantially normal to their planes of minimum thickness; and collecting energy from said accelerated groups of moving charged particles; whereby the velocity of said groups is increased without increasing their thickness, and the collector circuit is energized by high-frequency impulses.

11. In a high-frequency generating system utilizing high velocity charged particles in an evacuated region, the method of high-frequency generation which includes the steps of: forming a low velocity group of charged particles having a minimum dimension of length at right angles to the direction of motion; passing said group of charged particles laterally into an accelerator region of variable electrostatic field during a time interval when said variable field is zero; applying a retarding field to said low velocity group of such magnitude and duration as to at least reduce the low velocity of the group; increasing the field of said variable field region after said group is wholly within said variable field region, thereby accelerating said group in a direction substantially normal to the plane of minimum thickness of said group; passing said accelerated group of charged particles into an accelerator region of constant field during a time interval when the variable field is at least equal to the constant field; and collecting energy from said accelerated group of moving charged particles, whereby the velocity of said group is increased without increasing its length in the direction of accelerated motion, and the collector circuit is energized by a high-frequency impulse.

12. In a high-frequency generating system utilizing high velocity charged particles in an evacuated region, the method of high-frequency generation which includes the steps of: forming low velocity groups of charged particles simultaneously in parallel planes, said groups having a minimum dimension of thickness at right angles to their direction of motion; passing said groups of charged particles laterally into an accelerator region of controlled variable electrostatic field during a time interval when said field is substantially zero; applying a retarding field to said low velocity groups of such magnitude and duration as to at least reduce the given velocity of the groups; increasing the field of said variable field region after said groups are wholly within said variable field region, thereby accelerating said groups in a direction substantially normal to their planes of minimum thickness; passing said accelerated groups of charged particles into an accelerator region of constant field during a time interval when the variable field is at least substantially equal to the constant field; and collecting energy from said accelerated groups of moving charged particles; whereby the velocity of said groups is increased without increasing their thickness, and the collector circuit is energized by high-frequency impulses.

13. In a high-frequency generating system utilizing high velocity charged particles in an evacuated vessel, means for forming a group of charged particles having a given space dimension of length, means for directing said group along a given path, means for forming a series of regions defined by electrode members spaced along said given path, means for creating a field in any of said regions by controlling the voltage applied across said region, said field being controlled with respect to the passage of said group through said region, so that during the time interval of entrance of said group into said region said field is at most substantially equal to the field in the preceding region, and so that during the time interval of passage of said group from said region said field is at least substantially equal to the field in the following region, and so that any change in the strength of said field takes place during such time periods which result in producing an equal effect simultaneously upon all the charged particles in said group, and means for collecting energy from said accelerated group of moving charged particles, whereby the velocity of said group is increased without increasing its space dimensions of length and the collector circuit is energized by a high-frequency impulse.

14. In a high-frequency generating system utilizing high velocity charged particles in an evacuated vessel, means for forming groups of charged particles having given space dimensions of length, means for directing said groups successively along a given path, means for forming a series of regions defined by electrode members spaced along said given path, means for creating a field in any of said regions by controlling the voltage applied across said region, said field being controlled with respect to the passage of said groups through said region, so that during the time interval of entrance of said groups into said region said field is at most substantially equal to the field in the preceding region, and so that during the time interval of passage of said groups from said region said field is at least substantially equal to the field in the following region, and so that any change in the strength of said field takes place during such other time intervals as to produce an equal effect simultaneously upon

all the charged particles in said groups, and means for collecting energy from said accelerated groups of moving charged particles, whereby the velocity of said groups is increased without increasing their space dimensions of length and the collector circuit is energized by high-frequency impulses.

15. In a high-frequency generating system utilizing high velocity charged particles in an evacuated vessel, means for forming a moving group of charged particles having a given space dimension of length in the direction of motion, means for forming an accelerator region along the path of said group, means for timing the passage of said group into said accelerator region during a time interval when the field in said accelerator region is substantially zero, means for creating an electrostatic field in said accelerator region of such sense and timing as to simultaneously accelerate in the direction of motion all the particles of said group, thereby increasing the velocity of said group without increasing its length, and means for collecting energy from said accelerated group of moving charged particles, whereby the collector circuit is energized by a high-frequency impulse.

16. In a high-frequency generating system utilizing high velocity charged particles in an evacuated vessel, means for forming a moving group of charged particles having a given space dimension of length in the direction of motion, means for forming an accelerator region which is energized by a variable electrostatic field along the path of said group, means for timing the passage of said group into said accelerator region during a time interval when the electrostatic field in said accelerator region is substantially zero, means for increasing the electrostatic field of said variable field region, said variable field being of such sense as to accelerate said group in its direction of motion, means for forming a constant field region adjacent to and following said variable field region, means for timing the passage of said accelerated group of charged particles into the constant field region during a time interval when the variable field is at least substantially equal to said constant field, and means for collecting energy from said accelerated group of moving charged particles, whereby the velocity of said group is increased without increasing its space dimensions of length and the collector circuit is energized by a high-frequency impulse.

17. In a high-frequency generating system utilizing high velocity charged particles in an evacuated vessel, means for giving charged particles a given velocity, means for forming said charged particles of equal velocity into a given space patterned group having a given space dimension of length in the direction of motion, means for directing said group into a field free region, means for applying an accelerating electrostatic field equally and simultaneously to all the charged particles of the group, thereby increasing the velocity of the group without increasing its length, and means for collecting energy from said accelerated group of moving charged particles, whereby the collector circuit is energized by a high-frequency impulse.

18. In a high-frequency generating system utilizing high velocity charged particles in an evacuated vessel, means for giving charged particles a given velocity, means for forming said charged particles of equal velocity into substantially parallel flat-sided groups, means for directing said groups into a field free region, means for applying an accelerating electrostatic field equally and simultaneously to all the groups of charged particles, said accelerating field being substantially perpendicular to the planes of minimum thickness of said flat-sided groups, thereby increasing the velocity of the groups without increasing their space length in the direction of accelerated motion, and means for collecting energy from said accelerated groups of moving charged particles, whereby the collector circuit is energized by high-frequency impulses.

19. In a high-frequency generating system utilizing high velocity charged particles in an evacuated vessel, means for forming a group of moving charged particles having a given space dimension of length in the direction of motion, means for applying an accelerating variable field simultaneously to all the charged particles of the group, thereby increasing the velocity of the group without increasing its length, means for forming a region of constant field along the path of said moving group and next to said variable field region, means for timing the passage of said group into said constant field region during a time interval when the variable field is at least substantially equal to said constant field, thereby further increasing its velocity while in the constant field region, and means for collecting energy from said accelerated group of moving charged particles, whereby the collector circuit is energized by a high-frequency impulse.

20. In a high-frequency generating system utilizing high velocity charged particles in an evacuated vessel, means for forming flat-sided groups of charged particles in parallel planes, means for applying an accelerating variable field simultaneously to all the groups of charged particles, said accelerating field being substantially perpendicular to the planes of minimum thickness of the flat-sided groups, thereby increasing the velocity of the groups without increasing their space length in the direction of accelerated motion, means for forming a region of constant field along the path of said moving groups and next to said variable field region, means for timing the passage of said accelerated groups into said constant field region during a time interval when the said variable field is at least substantially equal to the said constant field in intensity, thereby further increasing their velocity, and means for collecting energy from said accelerated groups of moving charged particles, whereby the collector circuit is energized by high-frequency impulses.

21. In a high-frequency generating system utilizing high velocity charged particles in an evacuated vessel, means for forming a low velocity group of charged particles having a minimum dimension of length at right angles to the direction of motion, means for forming an accelerator region of variable field, means for directing said group of charged particles laterally into said accelerator region of variable field during a time interval when said variable field is substantially zero, means for applying a retarding field to said low velocity group of such magnitude and duration as to at least reduce the lateral velocity of the group, means for increasing the field of said variable field region after said group is wholly within said variable field region, thereby accelerating the said group in a direction substantially normal to the plane of minimum thickness of said group, and means for collecting energy from said accelerated group of moving charged particles, whereby the velocity of said group is

increased without increasing its length in the direction of final motion, and the collector circuit is energized by a high-frequency impulse.

22. In a high-frequency generating system utilizing high velocity charged particles in an evacuated vessel, means for forming low velocity groups of charged particles simultaneously in parallel planes, said groups having a minimum dimension of thickness at right angles to their direction of motion, means for forming an accelerator region which is energized by a controlled variable field, means for directing said groups of charged particles laterally into said accelerator region of controlled variable field during a time interval when said variable field is substantially zero, means for applying a retarding field to said low velocity groups of such magnitude and duration as to at least reduce the given velocity of the groups, means for increasing the field in said variable field region after said groups are wholly within said variable field region, thereby accelerating said groups in a direction substantially normal to their planes of minimum thickness, and means for collecting energy from said accelerated groups of moving charged particles, whereby the velocity of said groups is increased without increasing their thickness, and the collector circuit is energized by high-frequency impulses.

23. In a high-frequency generating system utilizing high velocity charged particles in an evacuated vessel, means for forming a low velocity group of charged particles having a minimum dimension of length at right angles to the direction of motion, means for forming an accelerator region which is energized by a variable electrostatic field, means for directing said group of charged particles laterally into said accelerator region of variable electrostatic field during a time interval when said field is substantially zero, means for applying a cancelling field to said low velocity group of such magnitude and duration as to at least reduce the low velocity of the group, means for increasing the intensity of said variable field after said group is wholly within said variable field region, thereby accelerating said group in a direction substantially normal to the plane of minimum thickness of said group, means for forming a region of constant field along the path of said accelerated moving group and next to said variable field region, means for timing the passage of said accelerated group of charged particles into said constant field region during a time interval when the variable field is at least substantially equal to the constant field, and means for collecting energy from the accelerated group of moving charged particles, whereby the velocity of said group is increased without increasing its length in the direction of accelerated motion, and the collector circuit is energized by a high-frequency impulse.

24. In a high-frequency generating system utilizing high velocity charged particles in an evacuated vessel, means for forming low velocity groups of charged particles simultaneously in parallel planes, said groups having a minimum dimension of thickness at right angles to their direction of motion, means for forming an accelerator region of variable field, means for directing said groups of charged particles laterally into said variable field region during a time interval when said variable field is substantially zero, means for applying a cancelling field to said low velocity groups of said magnitude and duration as to at least reduce the low velocity of the groups, means for increasing the intensity of said variable field after said groups are wholly within said variable field region, thereby accelerating said groups in a direction normal to their planes of minimum thickness, means for forming a region of constant field along the path of said accelerated moving groups and next to said variable field region, means for timing the passage of said accelerated groups of charged particles into said constant field region during a time interval when the variable field is at least substantially equal to the constant field, and means for collecting energy from said accelerated groups of moving charged particles, whereby the velocity of said groups is increased without increasing their lengths in the direction of accelerated motion, and the collector circuit is energized by high-frequency impulses.

25. In a high-frequency generating system utilizing high velocity charged particles in an evacuated vessel, an electron gun including energizing sources and control elements for forming and directing a moving group of charged particles of given length along a given path, at least two electrode members spaced along the given path to form an accelerator region and including energizing sources for applying a controlled voltage to the electrodes, said voltage being of such sense as to accelerate charged particles along the given path, a timing circuit joining said electron gun control elements and said accelerator region voltage control energizing source, said timing circuit timing the passage of said group into said accelerator region to occur during a time interval when the field in said accelerator region is substantially zero, and timing said accelerator field so that it is increased only after all the charged articles in said group are wholly within said accelerator region, and a collector electrode in the path of said accelerated group for collecting energy from said accelerated group of moving charged particles, whereby the collector oscillating circuit is energized by a high-frequency impulse.

26. In a high-frequency generating system utilizing high velocity charged particles in an evacuated vessel, an electron gun including energizing sources and control elements for forming and directing at least one group of charged particles of given space length into an accelerator region, at least three electrode members spaced along a given path to form at least a first and a second accelerator region, each of said accelerator regions including energizing sources for applying a voltage function to its boundary electrodes, said energizing source for said first accelerator region being controlled as to its variable voltage output, a timing circuit joining said electron gun control elements and said first accelerator region voltage energizing source, said timing circuit including means for timing the passage of said group into said first accelerator region during a time interval when its field is substantially zero, and means for timing the passage of said group out of said first accelerator region during a time interval when its field is at least substantially equal to the field of the following region, and a collector electrode in the path formed by each accelerated group for collecting energy from each accelerated group of moving charged particles, whereby the collector oscillating circuit is energized by each high-frequency impulse.

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