June 17, 1941. H. E. HOLLMANN 2,245,670

OSCILLATION GENERATOR

Filed Dec. 31, 1938 2 Sheets-Sheet 1

Fig. 1

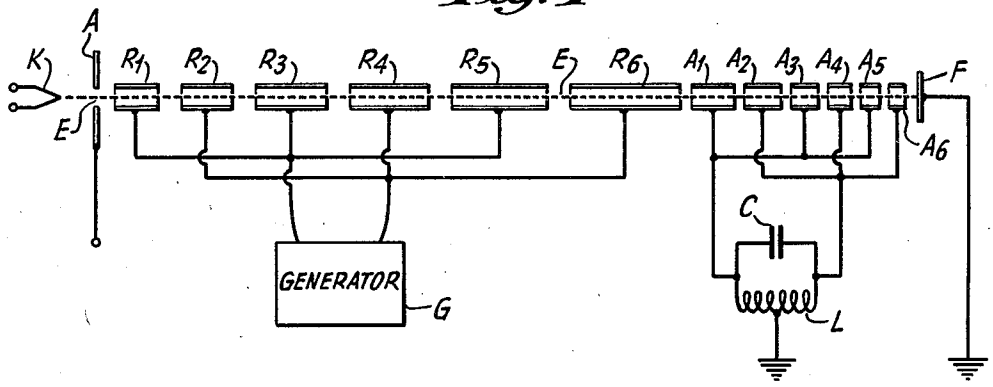

Fig. 2

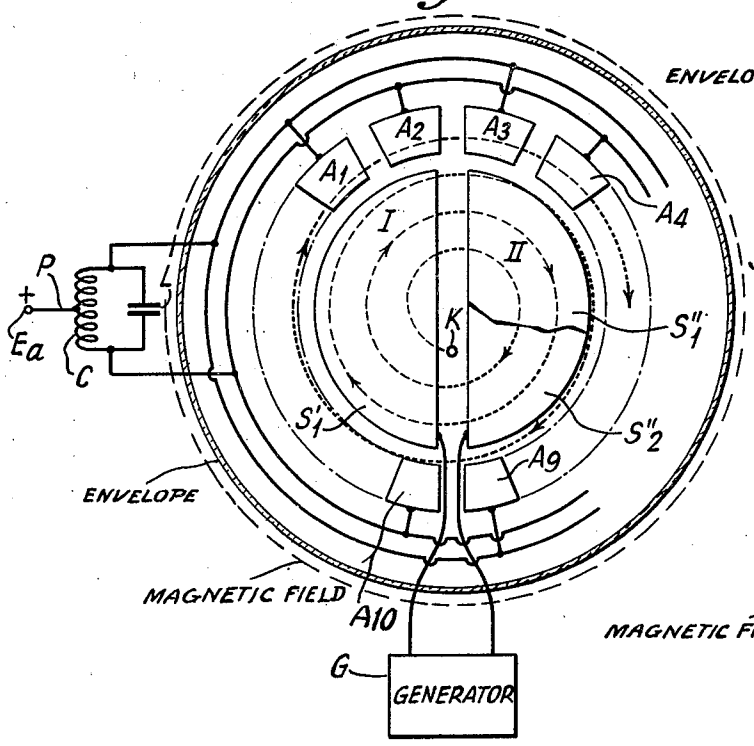

Fig. 2a.

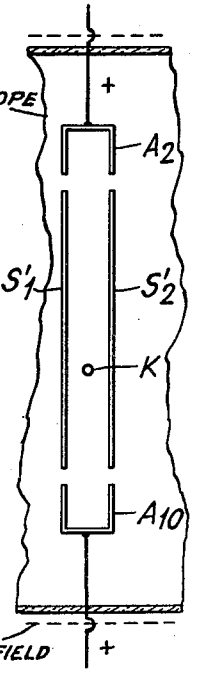

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Fig. 3

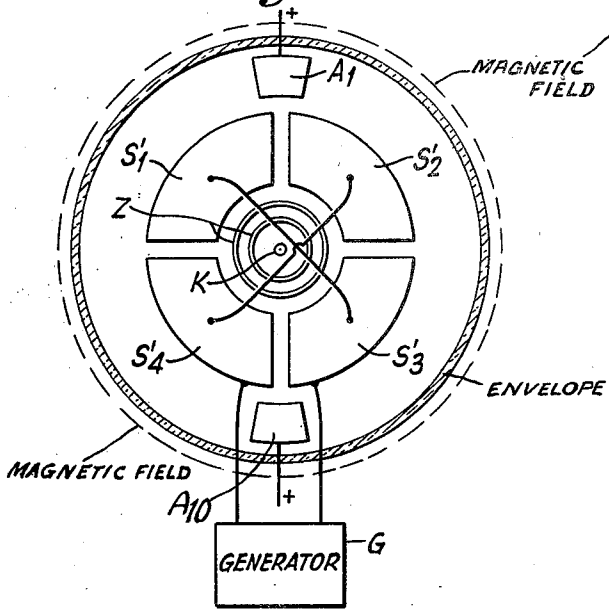


Fig. 3a

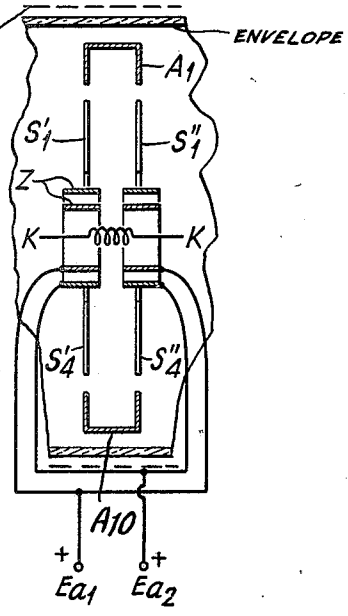


Fig. 4

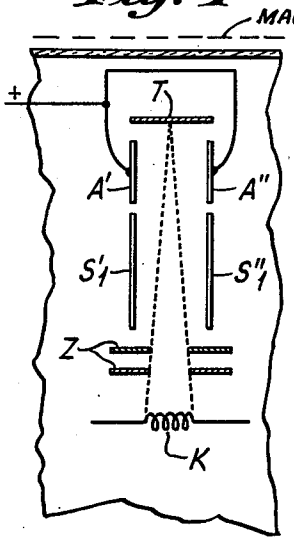


Fig. 5

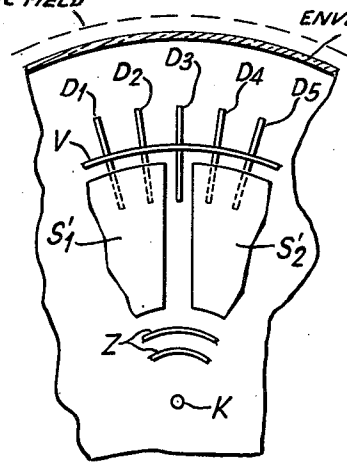
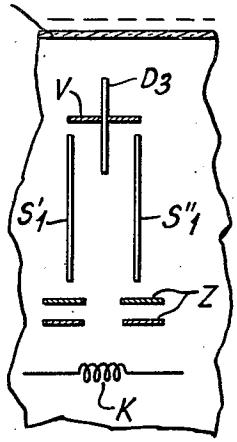


Fig. 5a



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Patented June 17, 1941 2,245,670

UNITED STATES PATENT OFFICE

2,245,670

OSCILLATION GENERATOR

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Application December 31, 1938, Serial No. 248,816
In Germany February 16, 1938

9 Claims. (Cl. 250—36)

It is known in the prior art that electrons may be accelerated to extremely high velocities by causing them to pass, at the proper rate of rhythm, consecutively through a great number of fields, the direction of which is alternately reversed so that the electrons again and again encounter an accelerative field. On the other hand, this process is reversible; in other words, a pencil or ray of electrons which is shot at a high rate of speed into an arrangement as just described, may be decelerated each time it passes from one field into the next field, incidentally yielding its energy, by influence action, to the field electrodes with the result that an oscillatory circuit associated therewith is excited to oscillations.

According to the invention, these two phenomena or actions are combined with each other in such a way that the electrons are first accelerated to very high speeds in sequential alternating frequency or radio frequency longitudinal fields, whereupon, at such high speeds as they have acquired, they are caused to enter into another part of the tube where, in similar fields, they are retarded or decelerated. By abbreviating several times the distances so traversed in comparison with the first accelerator part, it is thus possible to obtain appreciable frequency multiplications; that is to say, the periodicity of the uncoupling action may be diminished several orders of magnitude in comparison with the period of the acceleration process. At the same time, these high electron velocities allow the production of ultra short waves.

By reference to a simple tube scheme, the basic idea of the invention shall now be described and explained in more detail in its fundamental function and operation by reference to Fig. 1, given for the purpose of a clear understanding of the principles involved. An electron ray pencil E issuing from the cathode K and pre-accelerated by the anode diaphragm A enters into a row or bank of sequentially mounted tubes of small size indicated by R_1, R_2, R_3 . . . of growing length. Alternate tubes of this row R_1, R_3, R_5 . . . and R_2, R_4, R_6 . . . are connected together to result in two groups and are connected with the two terminals of an audio frequency or radio frequency generator G. If an electron is inside the first tube R_1 which happens to be charged negatively, it will not only find a free path ahead of it, but will even be attracted and be drawn into the next cylinder R_2. After having entered into this cylinder, the path is blocked. However, before the electron has reached this block, the potential has been reversed, and the electron experiences a new acceleration. It will be evident that the alternating frequency and the increment in the length of the tubes must bear a definite relationship to each other. But, in this manner a multiplicative resonant acceleration of the electrons is produced, and the result is that they leave the last tube at a far higher rate of speed than that which would correspond to the voltage interval of the alternating amplitude of generator G through which they have once passed.

According to the invention, the highly accelerated electrons enter into another row of small-sized tubes A_1, A_2, A_3 . . . These have a length appreciably smaller than the length of tubelets R, in fact the length of tubelets A becomes smaller and smaller. Also, these tubelets, here called uncoupling tubelets, similarly as tubelets R, are connected together in pairs, and they are associated with a suitable oscillatory circuit, say circuit L—C. Since the ray pencil is now no longer fed with energy, energy can only be yielded. In other words, the electrons impact the circuit L—C to experience oscillations corresponding to its natural wave-length, and the phase of the alternating potential thus produced at the two groups of uncoupling tubes A is just so that the electrons, upon their passage from one tubelet to the next, are decelerated or retarded. Actually, the electrons, by electrostatic induction, transfer portions of their energies to the L, C circuit. In order that in spite of such loss of velocity, the phases may be of the correct relationship, these tubelets, in contrast to tubelets R, must be shorter and shorter. Finally, that is to say, when leaving the last tubelet A_6, the electrons will strike the collector or gathering electrode F at such residual speed as they may still possess, and are conducted away by it. It will be evident that the energy which the electrons are able to yield to the oscillation circuit L—C originates in part from the anode voltage source E_a, but in major part from the feed generator G. It will also be readily understood that the frequencies of the generator potential must bear a relation to that of the excited circuit inversely to the lengths of the tubelets R_6 and A_6. Hence, it is thus feasible to secure an extremely high frequency ratio.

In the drawings, Fig. 1 is a simple type of circuit, given to aid in a clear understanding of the principles of the invention;

Figs. 2, 3, 4 and 5 show various practical embodiments of oscillation generators, in accordance with the invention; and

Figs. 2*a*, 3*a* and 5*a* are side views of Figs. 2, 3 and 5 respectively.

The principle underlying the invention, as thus far outlined, in its fundamentals is capable of a great many practical applications and embodiments as regards suitable combination and arrangement of the various parts of the tubes and the electrodes pertaining thereto. The exemplified embodiments hereinafter to be described, therefore, do not concern so much the disposition and construction of the two tube parts themselves, for these are known in the prior art in widely varying modifications, but they concern the most suitable ways and means of linking and coupling the constituent or elementary tubelets. For instance, with a view to saving space, the physical arrangement illustrated in Fig. 1 could be curved, the electrons being urged to keep on such required arcuate path by the provision of a constant magnetic field. Under certain circumstances, it is even possible to choose the curvature so that such electrons as have left the work or useful system are compelled to return to the accelerator system to be thus utilized several times.

An arrangement which is derived from the cyclotron known in the art, operates with an electron pencil which (by the agency of a magnetic field at right angles to the plane of the drawing) is caused to experience rapid rotations so that the pencil attains extremely high circumferential velocities. This pencil, therefore, could be compared to the armature of a rotary converter, the driving power of which originates from the supply generator G. Immediately after having left the stator, the pencil enters the stator of the generator part comprising a far greater number of poles, and it here induces alternating potentials of far higher frequency.

This practical embodiment of the basic idea of the invention shall be explained in greater detail by reference to the fundamental scheme shown in Figs. 2 and 2*a*. K denotes a source of electrons of any desired kind which is disposed between two circular plates or discs, each of the latter being divided into two semi-circular segments S_1' and S_1'', and S_2' and S_2'', respectively. Pairs of segments facing each other, that is S_1' and S_2', and S_1'' and S_2'', respectively, are jointly united with the terminals of an audio frequency or radio frequency generator G. The whole tube is traversed by a homogeneous magnetic field with force-lines at right angles to the plane of the drawing. The electrons issuing from K are first drawn into the positive semi-circular field I and they are curved into a roughly circular path so that they pass into the second field. Now, arrangements must be made so that the generator potential, during this time, has just been reversed, so that when the electrons pass from field I into field II they again experience acceleration. Owing to their raised speed, also the radius of curvature of the path or trajectory will be increased so that the electrons travel along an opening spiral at a rate of speed that is stepped up by leaps and bounds. What is important in connection with this arrangement is the fact that the time during which an electron describes a semi-circle in the magnetic field is given only by the intensity of the magnetic field irrespective of the velocity, with the consequence that an electron, once it has covered a semi-circle in the course of a semi-cycle or an alternation will do this also later on. The multiplicative resonant acceleration as described, if the tube is carefully adjusted, may be repeated hundreds of times, with the result that they gather considerable speeds at the periphery of the accelerator field, in spite of the fact that the feed voltage is, basically, rather low. Hence, the electron pencil can be likened to the armature of an electrical machine which is driven at extremely great circumferential speeds.

The high electron speeds existing at the periphery of the accelerator field are used for the generation of ultra short wave oscillations according to the inventiton. To this end, the accelerator field, throughout its circumference, is surrounded by a large number of uncoupling or delivery electrodes A_1, A_2, A_3 . . . mounted around a circle, the said electrodes being of U-shaped cross-section. These electrodes alternately are connected together to result in two groups A_1, A_3, A_5 . . . and A_2, A_4, A_6, and are associated with an oscillation circuit L—C. By way of the point of symmetry P of the latter, they are kept at a positive direct current voltage. Inasmuch as the electrons emerge tangentially from the accelerator field, they first continue to fly through the multiply-subdivided uncoupling field along a circular path, incidentally yielding their energy, in a manner as hereinbefore described, to the circuit L—C. However, they are incidentally retarded and by the action of the magnetic field they are bent together to result in a reduced radius of curvature, until after a multiplicity of convolutions or rotations, they impact the uncoupling electrodes and are thence conducted away.

Inasmuch as it is, basically, immaterial at what particular point in the center of the accelerator field the generation of the ray pencil takes place, it would also be feasible to employ a disc ray in connection with the frequency conversion here disclosed, as is true, for instance, of the arrangement illustrated in Figs. 3 and 3*a*. This embodiment differs from Fig. 2 only in so far as it comprises a central cathode K and a coaxial electron optic cylinder lens Z which consists, for instance, of four anode rings impressed with different potentials, these annular anodes leaving two annular gaps between themselves. As to the rest, the arrangement of the accelerator and uncoupling (delivery or output) electrodes is exactly the same as in Fig. 2; only the number of the accelerator electrodes has been raised to four. In lieu of a single ray pencil, this system is traversed by an electron-optically focussed disc ray the electrons of which, even when they emerge from the cathode, "roll" over circular paths, while, when they emerge from the cylinder lens, they are subject to resonant acceleration and in the uncoupling or output system to abrupt and jerky retarding actions. As to the rest, the effect and operation is the same as in the tube illustrated in Fig. 2, so that no further explanations will be needed.

A further improvement upon the embodiments shown in Figs. 2 and 3 results from an arrangement shown schematically in Fig. 4, where the uncoupling electrodes are disposed only upon both sides of the disc ray, and where opposite sheets A' and A'' are connected by a clip. The connection by groups, as in Figs. 2 and 3, is also used in this case. This affords a chance to cause the disc ray to impinge upon an external ring T being impressed with a direct current potential and to lead away such electrons as present the wrong phase.

The shorter the waves produced by the uncoupling part of the electron ray generator, the more

difficult it becomes to combine the uncoupling or output electrodes in a way as described to result in two groups and to tune them to the desired frequency. Where the frequencies are so high that the inductance of the connecting leads can no longer be disregarded, such steps as are usual in ultra short wave work may be resorted to for the purpose of tuning the different segments; that is to say, the segments may be regarded as the capacities and the connecting lines as the inductances of small oscillation circuits, all of which have the same frequency and are intercoupled by way of energy feeder lines or by radiation.

In lieu of the different segments there could, finally, be used also electrodes of a different shape, without departing from or altering the frequency change of the invention. A particularly illustrative example of an ultra-short wave generator is shown in Fig. 5 in the form of the uncoupling part of a tube according to the invention. Instead of the uncoupling segments and the exciting circuit associated therewith, a great number of radial dipole wires D_1, D_2, D_3 . . . are here distributed over the periphery of the accelerator field. They are supported by the ring V which at the same time insures the electrical connection of the dipoles in the nodal point of the oscillation and also closes the accelerator space from the outside. As a result, the dipoles have their inner halves immersed in the electron rotor, and they are excited at phases which are governed by their radiation coupling.

The invention is not restricted to the exemplified embodiments here shown; in fact, it is capable of being carried into effect in widely varying ways. For instance, any combination at all of electric and magnetic fields is feasible for the production of certain radiation paths.

What is claimed is:

1. The method of generating oscillations of high frequency in an electron discharge device which comprises accelerating electrons in a uniform magnetic field to cause the same to take a spiral path of increasing length but of constant angular velocity, subsequently retarding the flow of electrons and successively subtracting portions of the energies of said electrons during their retarded travel and utilizing the subtracted energy to produce oscillations of a desired frequency.

2. An electronic oscillator comprising a source of electrons, a plurality of spaced electrode structures adapted to be traversed by the electrons emanating from said source, means for driving said electrons past said electrode structure in curved paths of increasing radii, another plurality of spaced electrode structures adapted to be successively traversed by said electrons subsequent to the passage of said electrons past said first electrode structures, a tuned circuit, connections between alternately arranged electrode structures of said last plurality, and connections from adjacent electrode structures of said last plurality to opposite terminals of said tuned circuit, whereby said tuned circuit subtracts energy from said electrons to thereby establish and sustain oscillatory currents in said tuned circuit.

3. An ultra short wave oscillation generator comprising an even plurality of electrode structures arranged to substantially enclose an orbital space, an electron emitting electrode centrally located in said enclosed space, means for accelerating said electrons and causing the same to circulate in curved paths of increasing radii past said electrode structures, including a coil for producing a substantially uniform magnetic field within said space, a plurality of spaced electrode structures arranged around the periphery of said orbital space, a tuned circuit, a connection from one terminal of said tuned circuit to alternately positioned electrode structures of said last plurality, and a connection from the other terminal of said tuned circuit to the remaining alternately positioned electrode structures of said last plurality, whereby said electrons are decelerated as they pass by said last electrode structures and deliver energy to said tuned circuit.

4. An ultra short wave oscillation generator comprising an even plurality of electrode structures, greater than two, arranged to enclose an orbital space, an electron emitting electrode located substantially centrally in said enclosed space, means for producing a substantially uniform magnetic field within said space, connections between alternately arranged electrode structures, a source of alternating current having its terminals connected to said electrode structures such that adjacent electrode structures have opposite instantaneous polarities, a plurality of spaced electrode structures arranged around the periphery of said orbital space, a tuned circuit, a connection from one terminal of said tuned circuit to alternately positioned electrode structures of said last plurality, and a connection from the other terminal of said tuned circuit to the remaining alternately positioned electrode structures of said last plurality, whereby said electrons are decelerated as they pass by said last electrode structures and deliver energy to said tuned circuit.

5. An electronic oscillator comprising within an evacuated envelope a source of electrons, an even plurality of spaced electrode structures adapted to be successively traversed by the electrons emanating from said source, means for driving said electrons past said electrode structures with successively accelerated speeds, another plurality of spaced electrode structures adapted to be successively traversed by said electrons subsequent to the passage of said electrons past said first electrode structures, a tuned circuit, connections between alternately arranged electrode structures of said last plurality, and connections from adjacent electrode structures of said last plurality to opposite terminals of said tuned circuit, whereby said tuned circuit subtracts energy from said electrons to thereby establish and sustain oscillatory currents in said tuned circuit.

6. The method of operating an electron discharge device which comprises the steps of successively accelerating electrons in a uniform magnetic field, subsequently successively subtracting energy from said electrons with a consequent continual deceleration thereof, and utilizing the subtracted energy to produce ultra high frequency oscillations.

7. The method of operating an electron discharge device which comprises the steps of successively accelerating electrons in a uniform magnetic field to cause the same to take a spiral path of increasing velocity, subsequently successively subtracting energy from said electrons with a consequent continual deceleration thereof, and utilizing the subtracted energy to produce ultra high frequency oscillations.

8. The method of operating an electron discharge device which comprises the steps of successively accelerating electrons in a uniform

magnetic field to cause the same to take a spiral path of increasing length but of constant angular velocity, and subsequently successively subtracting energy from said electrons during their travel over substantially the longest spiral path, and utilizing the subtracted energy to produce ultra high frequency oscillations.

9. An electronic oscillator comprising a source of electrons, a plurality of spaced electrode structures adapted to be traversed by the electrons emanating from said source, means for driving said electrons past said electrode structures in curved paths of increasing radii, another plurality of spaced electrode structures adapted to be successively traversed by said electrons subsequent to the passage of said electrons past said first electrode structures, each of said last electrode structures comprising a dipole conductor, whereby said electrons are decelerated as they pass by said dipole conductors and deliver energy thereto.

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