

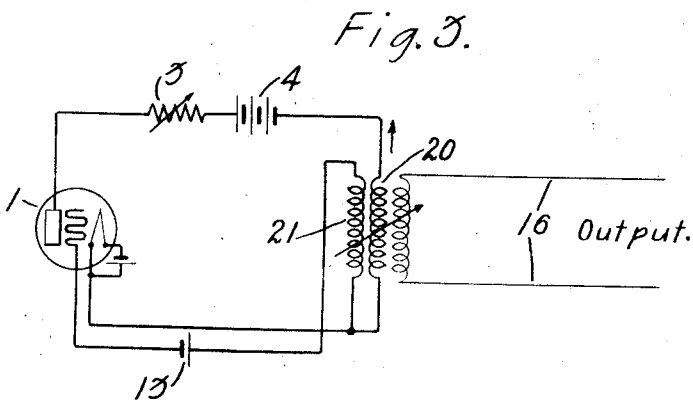
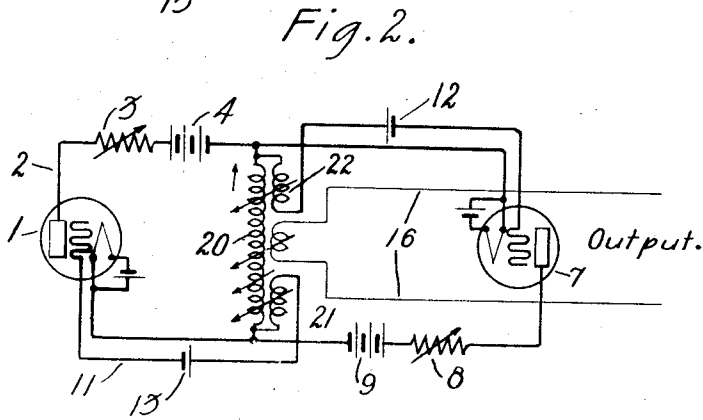
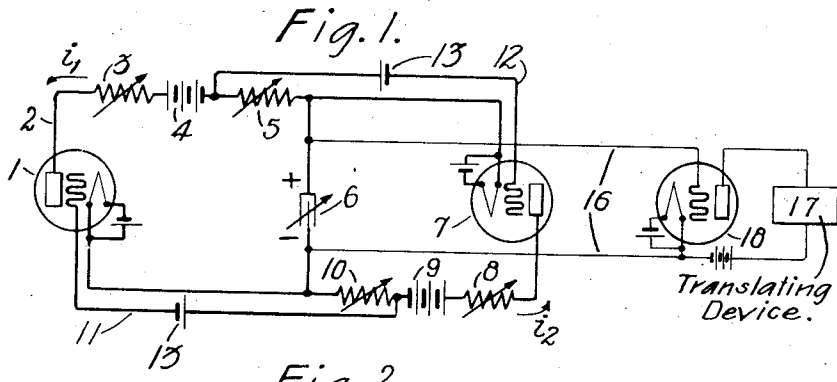
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NONRESONANT SYSTEM

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UNITED STATES PATENT OFFICE.

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NONRESONANT SYSTEM.

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This invention relates to methods and means for generating alternating currents.

A well-known type of oscillation generator is that in which one or more tuned circuits containing inductance and capacity, in which oscillations are to be produced, are associated with a highly evacuated electron discharge device having an anode, a heated electron-emitting cathode, and an impedance varying element. Such a device is commonly known as an audion and functions to set up and maintain the desired oscillations. The frequency or frequencies of the oscillations produced by such an arrangement will depend principally upon the tuning of the tuned circuit or circuits.

It has been found, however, that it is possible to construct such a generator without a tuned circuit, the frequency of the generated oscillations being determined by the magnitude of the electrical constants of certain other elements included in the arrangement. The period of any inherently unstable system whose condition changes cyclically is in general a function of the stiffness factor and the inertia factor of the system. Any such system wherein one or the other of these factors is negligible may be styled a "non-resonant system".

The expression "non-resonant generating system", as herein applied to electrical systems, is intended to define a generating system in which oscillations are set up by virtue of electrical energy from a source of current in a circuit being alternately stored up by a reactance and discharged, the frequency of the generated oscillations being independent of one of the usual frequency determining means,—capacity and inductance. In case both capacity and inductance are included in such a system they are so related as not to constitute a resonant circuit and thereby determine the oscillation frequency.

An object of the invention is to provide improved arrangements wherein one or a plurality of impedance varying devices, preferably electron or equivalent discharge devices, are associated with a non-resonant circuit or circuits to function as a generator of oscillations.

A further object is to provide such a generator in which capacity and resistance means are combined with an amplifying device, no inductance elements being included,

and any incidental inductance of the connecting conductors being negligible and wholly unessential to the operation of the system.

A further object is to provide such a generator containing a pair of amplifiers oppositely connected to an impedance element for the generation of symmetrical oscillations.

A further object is to provide means such as herein described whereby alternating current of non-sinusoidal wave form as, for example, flat-topped or other symmetrical waves, may be produced.

A further object is the provision of efficient means for the production of low frequency oscillations.

Other objects are the provision of various improved details tending toward the production of simple, efficient, stable and easily adjustable non-resonant generators, as will appear after consideration of the following detailed description. Certain novel features of the described systems, moreover, are of utility in other than generating systems and are therefore claimed broadly.

The invention is illustrated in the accompanying drawing, wherein Fig. 1 represents a form of non-resonant generator in which two discharge devices and a capacity are included; Fig. 2, a similar form in which inductance elements but no capacities are used; and Fig. 3, a modification of Fig. 2 in which only one of the two symmetrically arranged halves of the system of Fig. 2 is employed.

In Fig. 1 the anode-cathode circuit 2 of the vacuum tube or audion 1 includes the variable resistance 3, a source of current 4, variable resistance 5, and condenser 6. The anode-cathode circuit of tube 7 includes variable resistance 8, source 9, resistance 10 and condenser 6. Under certain conditions the resistances 3 and 8 may be of small or zero value. The condenser 6 is connected to the anode-cathode circuit of one of the tubes in a manner opposite to that in which it is connected to the anode-cathode circuit of the other. The input circuit 11 of tube 1 so includes the resistance 10 that increase of current through tube 7 and resistance 10 makes the grid of tube 1 more negative. The input circuit 12 of tube 7 is connected to the resistance 5 in a corresponding manner. Batteries 13 are provided for maintaining

the grids or impedance-controlling elements of the tube at any suitable average potential with respect to their respective cathodes. All leads and resistance elements are preferably designed to have minimum self-induction. Tubes 1 and 7 typify any suitable discharge devices or systems of discharge devices.

The parts so far described constitute a non-resonant generator. For utilizing the alternating electromotive force produced thereby any suitable means, for example, an output line 16, may be connected to the system in any suitable manner, as, for example, across the condenser 6. The output line leads to any load translating device 17. A thermionic repeater 18 may be connected in the line 16 because of its unidirectionally conducting properties and amplifying power. The device 18 serves to provide increased current of the generated wave form and to prevent reaction of the translating device upon the generating system.

Operation of the system of Fig 1.

Suppose the circuit is so designed and the elements so proportioned that an increase in current i_1 through tube 1 causes a sufficiently large difference of potential between the terminals of resistance 5, that flow of current i_2 through tube 7 will be reduced to zero or a small value. Similarly, an increase of current i_2 will cut off or substantially reduce the current i_1 through tube 1. Assume, moreover, a disturbance of equilibrium whereby the condenser 6 is charged as indicated in the drawing, then the voltage across condenser 6 is added to that normally existing in the anode-cathode circuit of tube 1 and is subtracted from that in the anode-cathode circuit of tube 7. As a result, i_1 is increased and i_2 decreased. The increase in i_1 cuts off i_2 or reduces it to a smaller value. This in turn, by removing the voltage across resistance 10, tends to increase i_1 still more. As i_1 is increased, all the current i_1 must be supplied from the condenser, so that the voltage across the condenser decreases. Upon reaching the normal or uncharged condition, the condenser becomes charged in the opposite direction because when the charge upon condenser 6 has reached zero, i_1 is still greater than its normal or average value. At this instant the grid of tube 1 will have a potential above its average value and the grid of tube 7 a lower value. Consequently, it is not until the charging of the condenser in the reverse direction has reduced the anode-cathode voltage across the tube 1 to a value where the current through tube 1 begins to decrease, that the grid voltage of the tube 7 becomes high enough or sufficiently reduced from a negative value, that current i_2 begins to flow or increase. As soon as this happens, the increased potential difference across resistance 10 cuts off i_1 . Simultaneously i_2 is further increased by the increase of grid voltage due to the decrease of potential difference between the terminals of resistance 5. This process continues indefinitely and hence an alternating potential difference is produced across the terminals of the condenser 6. While this potential difference may in some instances be directly applied to a translating device, it will be advantageous to provide a potential-operated repeating device 18 whose output circuit supplies the current to be utilized. The unidirectionally conducting properties of the device 18 serve to prevent variations of electrical condition of the load device 17 from affecting the oscillatory condition of the generating system. While the device 18 will produce a small capacity effect in parallel with capacity 6, this will usually be negligible.

The generated wave form will tend to be symmetrical and square-topped rather than sinusoidal and will approach a more nearly sinusoidal form as the amplitude is decreased, which may be accomplished by increasing the resistances 3 and 8 or decreasing the mutual impedances between the two tubes, i. e. resistances 5 and 10. The frequency is dependent to some extent upon every constant of the system but it may be varied over a considerable range by variations in capacity 6.

The system of Fig. 2 utilizes inductances but no capacities. The elements in general correspond to those described in connection with Fig. 1, as will be seen by comparison of the corresponding reference numbers. However, inductance 20 is substituted for the capacity 6. The inductances 21, 22 are coupled to inductance 20 in such a manner that increase of current in the direction of the arrow through inductance 20 makes the grid of tube 1 less negative and the grid of tube 7 more negative. This system therefore depends for its operation upon the electromagnetic induction between the input and output circuits. The action will be improved by designing the system so that electrostatic effects will be reduced to a minimum.

Operation of the system of Fig. 2.

Assume an increasing current flowing in the direction of the arrow. This makes the grid of tube 1 more positive and the grid of tube 7 more negative. The impedance of tube 1 is therefore decreased and of tube 7 increased. Current through tube 1 is further increased up to some maximum value as determined by resistance 3, constants of tube 1, and the potentials of batteries 4 and 13. As soon as the current through the tube 1

ceases to increase or begins to increase at a lower rate, the grid of tube 1 becomes less positive or more negative, as the case may be, since it is the increased potential—in a positive sense—on the grid of tube 1, which lowers the impedance of the tube sufficiently to allow the increased current to pass there-through. As soon as the positive potential on the grid ceases to be maintained, the increased flow of current cannot be maintained. As soon as the current begins to decrease, the transformer action between coils 20 and 21 decreases the potential of the grid of tube 1, thereby still further decreasing the current. Meanwhile, the grid of tube 7 has become more positive—or less negative—and the current through it begins to flow or increase. The last-mentioned current is in a direction in the coil 20 opposite to that in which the current through the tube 1 flows. When the current through the tube 7 exceeds that through the tube 1, the current through the coil 20 reverses and a cycle of operations occurs in the tube 7 similar to that described for the tube 1. This action will be maintained indefinitely, provided the total amount of the energy dissipated in the system and in the output circuit 16 is not too great.

Fig. 3 illustrates a system employing a single discharge device or amplifier and comprising one of the symmetrically arranged halves of the system of Fig. 2. The operation of this system is similar to that of the system of Fig. 2. The inductances 20, 21 must, as in the arrangement of Fig. 2, be coupled so that increasing current through coil 20 in the direction of the arrow, renders the grid of tube 1 more positive or less negative. The amplitude and frequency may be regulated by varying the electromotive force of source 4, resistance 3, inductance 20, 21 and the mutual inductance therebetween. Inasmuch as the electrostatic inductive effect between the grid and the anode of the tube 1 may tend to cause the device to produce oscillations in a manner analogous to previously known types of oscillation generators with a frequency depending upon the capacity, between the grid and the anode of tube 1, and the inductances 20, 21 and the mutual inductance therebetween, the variable elements of the system are so adjusted as to prevent this action. In general, this may be accomplished by adjusting the system so that the mutual conductance between the grid and plate circuits is too small to support undesired oscillations of the frequency which tend to occur. The mutual conductance may be reduced in various ways which are known to those skilled in the art, such as changing the coupling between coils 20 and 21, making the inductance of coil 21 relatively small, or by increasing the resistance 3. Undesirable oscillations of any

frequency which tend to occur will be of relatively high frequency because of the small magnitudes of the grid-plate capacity, the other internal capacities of the tube and the distributed capacities of the associated coils.

The novel features inherent in the invention are defined in the appended claims.

What is claimed is:

1. A non-resonant oscillation generator comprising a pure electron discharge device, an anode, a cathode, and an impedance controlling element therefor, an output circuit connected to the anode and the cathode, a feed-back connection from the output circuit to the impedance controlling element, said output circuit containing a resistance external to said device, said output circuit containing reactance of one kind only which is effective in controlling the frequency of the oscillations generated.

2. A generating system comprising a series circuit, said series circuit containing consecutively arranged current sources, anodes, and electron-emitting cathodes, said sources being so connected as to tend to drive current in the same direction through said circuit, in combination with a frequency determining reactance.

3. A system comprising a plurality of electron-discharge repeaters, means tending to drive current through each repeater, and electrostatic control means operated by flow of current through each of said repeaters tending to reduce the simultaneously existing current through the other repeater.

4. A non-resonant oscillation generator comprising a highly evacuated electron discharge tube, a capacity and a resistance in circuit with said tube, and a circuit through said capacity of negligible inductance for establishing the periodicity of said generator.

5. A non-resonant oscillation generator comprising an energy storing electric capacity and an energy dissipating device of negligible inductance connected thereto, said dissipating device and the electric capacity constituting a non-resonant frequency determining circuit, and an electric discharge device for periodically reversing the current flow in the circuit comprising said energy dissipating device and said energy storing electric capacity.

6. A non-resonant oscillation generator comprising electron discharge means, impedance controlling means therefor, and a capacity connected to said discharge means, said capacity being included in a non-resonant frequency determining circuit.

7. A non-resonant oscillation generator comprising a highly evacuated electron discharge tube, a capacity, and connecting impedance means, said capacity and said impedance means constituting a non-resonant frequency determining circuit.

8. A non-resonant oscillation generating system comprising a pair of thermionic discharge tubes having anodes, circuits therefor, and a capacity oppositely connected conductively to corresponding anodes of said tubes by conductors of negligible inductance.
9. An electrical system comprising a network of circuits having several conductive paths in an unvarying state of continuity, a capacity in said system, and means whereby said capacity is successively charged through one of said paths and discharged through another path, said last mentioned paths having their common portion of negligible impedance except for the impedance of said capacity.
10. A system comprising a network of circuits having several unsymmetrically conducting branches in an unvarying state of continuity, a capacity in said network, and means whereby said capacity is discharged and charged by each of said branches in succession and impedance controlling means for varying the discharge through each of said branches.
11. A system comprising a pair of vacuum tubes each having an anode, a cathode and an impedance-varying element, a capacity connecting said cathodes, anode-cathode circuits for each of said tubes, each of said circuits containing said capacity and two resistances, an input circuit for each of said tubes, each input circuit comprising one of said resistances in the anode-cathode circuit of the other tube, a wave utilizing circuit connected across said capacity, and a voltage operated unidirectionally transferring device for current in said utilizing circuit.
12. A system comprising a capacity, a plurality of unidirectionally conducting paths having negligible inductance connecting the terminals of said capacity, and means whereby current-flow in one of said paths tends to increase the impedance of another of said paths.
13. A system comprising a capacity, a plurality of unidirectionally conducting paths of negligible inductance connecting the terminals of said capacity, and means whereby variation in current-flow in one of said paths causes simultaneous variation in impedance of another of said paths.
14. An oscillation generator comprising a branched circuit, a source of current in said circuit, a capacity in one branch of said circuit, an impedance-varying device in each of a plurality of said branches, means associated with each of said impedance-varying devices responsive to current in said circuit for controlling the impedance-varying devices respectively, and means for determining the frequency of oscillations substantially independent of inductive reactance.
15. A non-resonant oscillation generator comprising a space discharge device having an electron emitting cathode, an anode, and a space impedance control element, and a circuit of negligible inductance containing resistance and capacity whose time constant primarily determines the frequency of said generator.
16. An electrical system comprising a pair of space discharge devices, a branch circuit having capacitative reactance at all frequencies, and means whereby the direction of current flow through said branch determines the relative impedance of said devices.
17. An electrical generating system comprising means for establishing a plurality of electron streams in space, an electrostatic control means for each stream, a path having reactance of the same kind for a large range of frequencies both above and below the generated frequency in series with the space path of each stream, and means controlled by the direction and intensity of current in said path for acting on said streams through said control means.
18. In thermionic apparatus, the combination of a plurality of ionic tubes, each having a filament, a grid and an anode, connections including sources of current between the anode of one tube and the grid of a second tube in said apparatus, and between the anode of said second tube and the grid of said first mentioned tube, and a common branch connection including high ohmic resistances in the anode and grid circuits of both of said tubes, whereby the anode of one tube and the grid of the second tube in said apparatus are connected, and the anode of said second tube and the grid of the first mentioned tube are connected, to form a closed circuit cascade system.
19. In thermionic apparatus the combination comprising a plurality of thermionic tubes, each of said tubes containing a filament, a grid and an anode, electrical circuits between the anode and filament and the grid and filament of each tube, means for supplying current to the electrical circuits, the anode of one tube and the grid of a second tube, and the anode of the second tube and the grid of the first tube being arranged in a closed cascade system, and a plurality of high ohmic resistances in the common branch between the two tubes.
20. In thermionic apparatus the combination comprising a plurality of thermionic tubes each having a filament, a grid and an anode, anode and grid circuits for said tubes, the grid circuit of one tube being connected to the anode circuit of a second tube, whilst the grid circuit of the second tube is connected to the anode circuit of the first tube, a plurality of high ohmic resistances, one of the resistances being in-

cluded in the common branch for the anode circuit of the first tube and the grid circuit of the second tube, and one of the high ohmic resistances being included in the common branch for the anode circuit of the second tube and the grid circuit of the first tube.

21. In thermionic apparatus comprising a plurality of thermionic tubes, each having a filament, a grid and an anode, anode and grid circuits for said tubes, the grid circuit of one tube being connected to the anode circuit of a second tube while the grid circuit of the second tube is connected to the anode circuit of the first tube, a plurality of high ohmic resistances, one of the resistances being included in the common branch for the anode circuit of the first

tube and the grid circuit of the second tube and the other of the high ohmic resistances being included in the common branch for the anode circuit of the second tube and the grid circuit of the first tube, means connecting the grid of a third tube included in the apparatus to the anode circuit of the first tube and the filament of the third tube to the anode circuit of the second tube, said connections being such that the electromotive forces set up in the first two tubes are applied to the grid filament circuit of the third tube and effect changes in the anode circuit of said third tube.

In witness whereof, I hereunto subscribe my name this 30 day of January A. D., 1919.

RALPH V. L. HARTLEY.