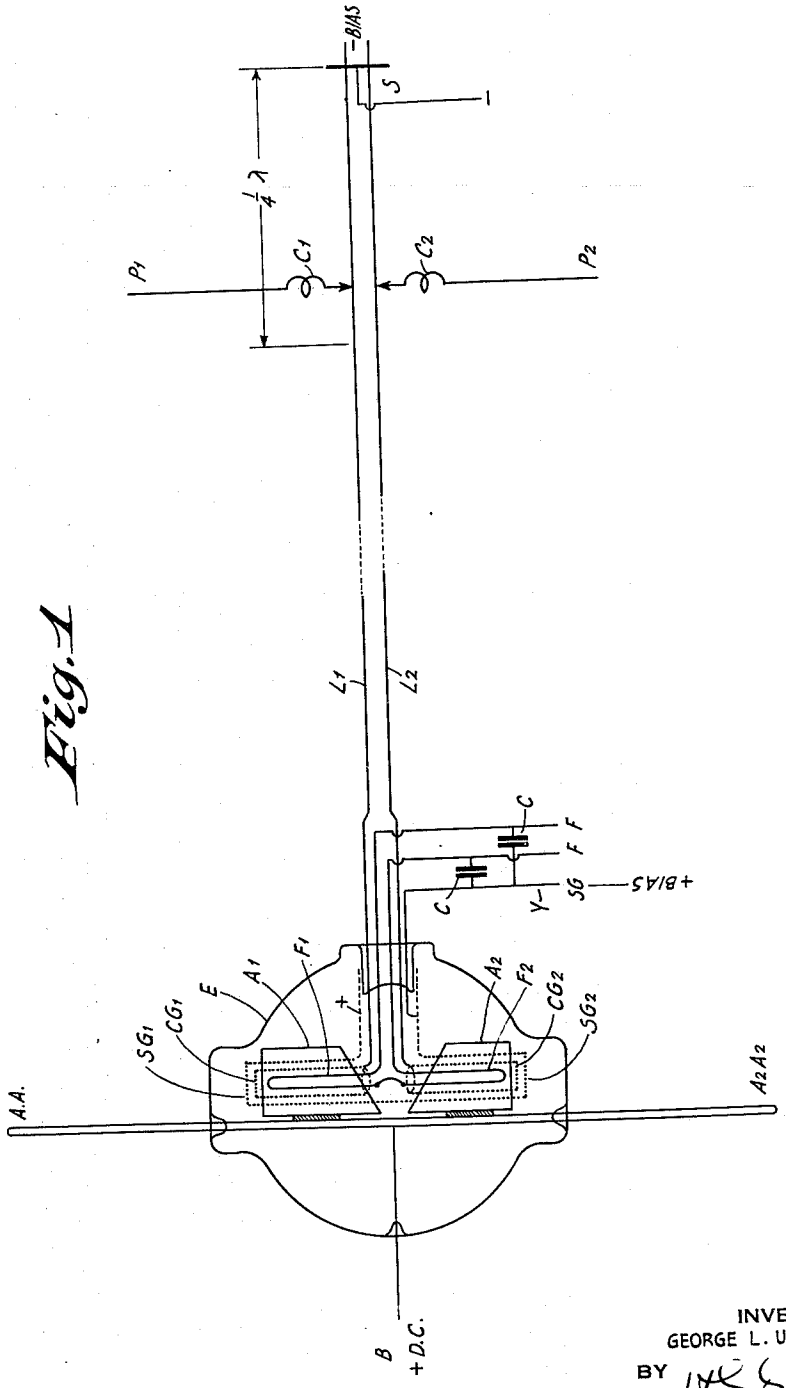
Oct. 13, 1936. G. L. USSELMAN 2,057,170

OSCILLATION GENERATION

Filed Oct. 7, 1932 2 Sheets-Sheet 1

Fig. 1



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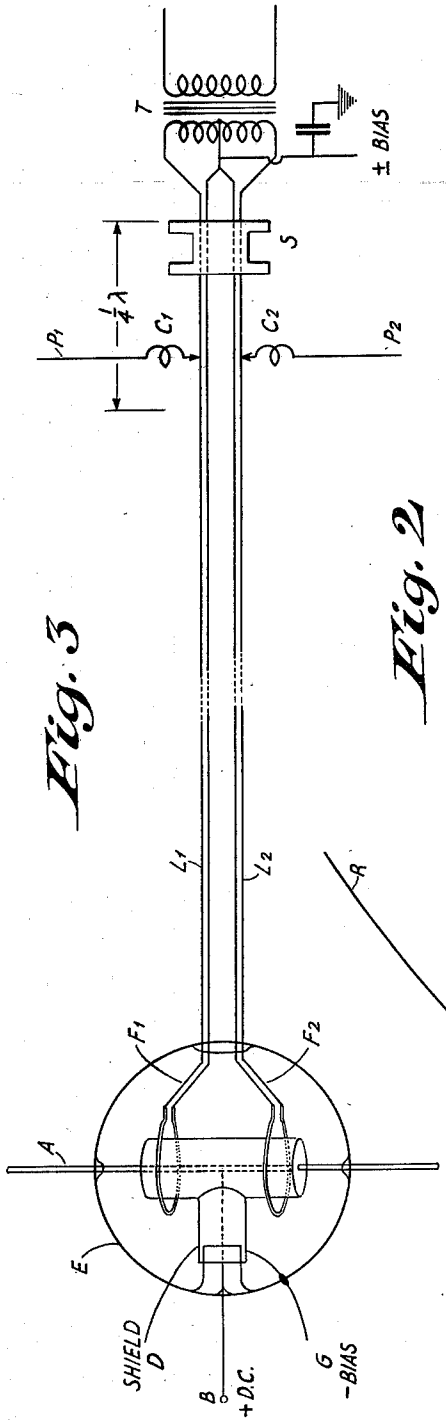


Fig. 3

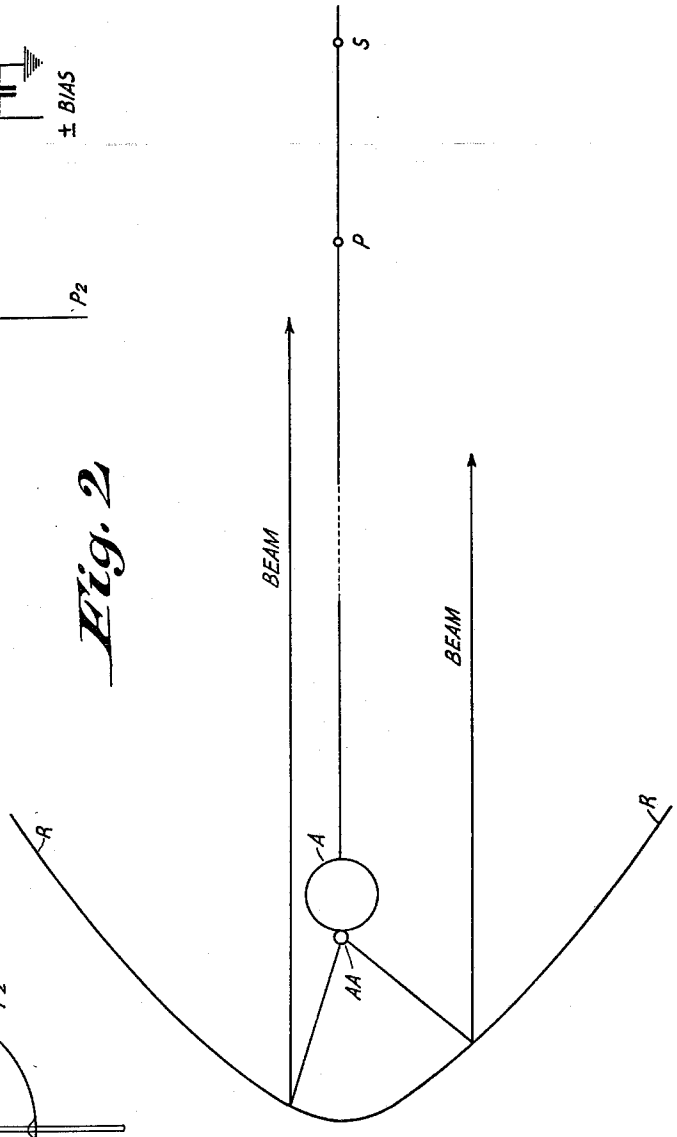


Fig. 2

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2,057,170

OSCILLATION GENERATION

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Application October 7, 1932, Serial No. 636,710

18 Claims. (Cl. 250—36)

It has been proposed, for frequency control, to couple the end of a transmission line inductively or capacitively to the plate or output circuit of an electron discharge device generator and the other end of the transmission line to the grid or grids of the generator. The length of the line was adjusted so that the phase of the energy when it arrived at the grid was such as to produce maximum stability of frequency.

As the above method of coupling the line to the generator does not lend itself so well to ultra high frequency practice, the object of my present invention is to provide a suitable frequency controlling circuit for an ultra short wave generator, which however, takes advantage of long line phenomena but avoids the coupling difficulties mentioned. To fulfill this object, I provide a space wave pick-up circuit in combination with a transmission line for controlling the frequency of the electric generator of very short waves or oscillations. In brief, I propose to pick up, at some distance away, some of the radiated energy from the generator and to transmit it back to the grids or control electrodes of the generator to control the frequency thereof.

That is, my present scheme, using the space wave pick-up, is more suited for feeding energy into the input end of the frequency control line for very high frequencies and offers the advantages of flexibility in phase and amplitude adjustment. Also it offers an alternate method of energy pick-up for long line frequency control which has proven very satisfactory at high frequencies.

I shall explain my invention more fully hereinafter with the aid of the accompanying drawings, wherein,

Figure 1 diagrammatically indicates a short wave system utilizing the combination of a space wave pick-up and a long transmission line, a plurality of half wave lengths long at a desired operating frequency for frequency control;

Figure 2 is a top plan view of Figure 1 having in addition a reflector for the radiating antenna; and,

Figure 3 illustrates a further modification of my present invention.

Referring to Figure 1 E is the glass envelope inside of which are the tube elements. The gas inside the envelope may be of any element and any pressure but preferably it should be of very low pressure ordinarily spoken of as a vacuum. A_1A_1 and A_2A_2 constitute the anode-antenna to the center of which is connected the anode current supply lead B. Positive plate potential is maintained through this lead by an outside power source. The tube anodes A_1 and A_2 are welded to the anode antenna in the position as illustrated. These are thin metal cylinders, located coaxially with relation to each other and are welded on each side of the center of the anode antenna whose axis is parallel with that of the cylinders. There is a V space between the inner ends of the tube anodes A_1 and A_2 where the leads enter and connect to the internal elements.

Inside of the anodes are the screen grids SG_1 and SG_2. The two screen grids are joined at the center and a third arm X of it extends out over the leads, and clamps on the glass envelope for support. The control grids CG_1 and CG_2 are located inside the screen grids. The control grids do not join at the center and each has a separate lead. It should be mentioned here that the screen grids have a common bias lead Y. Inside of each control grid is mounted the filament F_1 and F_2. The filaments may be connected in parallel or in series. Preferably they should have a common pair of leads FF.

The screen grid lead is connected to each filament lead by means of the by-pass condensers C. The long lines L_1 and L_2 a plurality of half wave lengths long at a desired operating frequency, are connected to control grid leads CG_1 and CG_2. The long lines have uniformly distributed inductance and capacity and are arranged close together or concentrically to prevent radiation. The other end of the lines is shorted by the bar S. Negative bias voltage is supplied through the center point of this bar and through the long lines to the control grids. The pick-up wires P_1 and P_2 may be connected to the lines L_1 and L_2 any distance from the bar up to one-quarter of the operating wave length. The coils C_1 and C_2 are for adjusting the tuning of P_1 and P_2 to the radiated wave. The pick-up wires should be parallel to the anode antenna. Figure 2 shows the position of the parabolic reflector R in relation to the anode antenna and the pick-up wires.

In operation, the generator of Figures 1 and 2 is similar to that of a pushpull oscillator. When the generator is oscillating the function of the space wave pick-up and long line is as follows: The energy (of ultra high frequency) is radiated from the anode antenna A_1A_1 and A_2A_2. The reflector R will direct the beam along the lines L_1 and L_2 to the end of which is connected the radiation pick-up unit P_1 and P_2. Some of this radiated energy causes high frequency current and voltage to be set up in the pick-up wires P_1 and P_2. This energy is transmitted to the

lines L_1 and L_2 which in turn transmit it back to the generator control grids CG_1 and CG_2. By properly adjusting the distance of the pick-up wires P_1—P_2 from the anode antenna A_1A_1—A_2A_2 and by properly adjusting the length of the long lines L_1 and L_2, the phase of the energy arriving over the long line to the control grids can be made to aid and maintain the oscillations in the generator anode antenna.

The phase relation of grid voltage will be approximately 180 degrees from that of the plate voltage for a range of high frequencies. For ultra high frequency work the phase of the grid voltage will have to be in advance of 180 degrees to compensate for the time required for the electrons to reach the anode, i. e. the electrons must reach the anode when it is minimum positive potential.

The amount of energy picked up on P_1 and P_2 may be regulated by adjusting the length of P_1 and P_2. The tuning of the pick-up may be maintained by adjustment of coils C_1 and C_2.

The approximate frequency to be maintained will depend on the length of the anode antenna. It should be approximately half (in length) of the operating wave length. The exact adjustment will be made by adjusting the length of the long line L_1—L_2 and the distance between the pick-up wires and the generator antenna. The operation of the space wave and long line combination is similar to the long line method of frequency control described by James L. Finch and James W. Conklin in their United States Patent No. 1,945,545, and by Clarence W. Hansell in his United States Patent No. 1,945,546, both granted February 6, 1934. This combination will function to maintain constant frequency because any small change in frequency of the generator will cause a large change in the phase relation between the anode voltage and the energy returning to the grids from the pick-up wires and the long line. It would also be difficult for the generator to change its frequency because the grids are controlled by the energy which has been already radiated. If the pick-up wires are placed several wave lengths away from the generator antenna then the pick-up arrangement cannot be directly affected by induction or capacity from the generator. The pick-up arrangement which I have shown is only for illustration of the principles involved and may consist of a more elaborate arrangement for performing the above function.

A modification of my present invention is shown in Figure 3 wherein a different form of generator is utilized. The anode A is approximately a half wave doublet or linear radiator. This is connected at the center to a positive voltage supply lead B. The central portion of the doublet anode and part of the lead B is surrounded by a shield D on which is maintained a negative bias voltage. Outside the shield and spaced a short distance each side of the center of the anode are two filaments F_1 and F_2. Connected to F_1 are two transmission lines L_1, and to F_2 are connected two other lines L_2. The ends of these long lines are connected to the filament transformer T. The shorting bar S serves to adjust the length of the long line L_1—L_2. The bar S is, in this case, only capacitively coupled to the lines to prevent short circuiting of the filament supply. The capacity between conductive plate S and the lines is such as to constitute an effective short circuit at the operating frequencies, thereby maintaining the line at S at a voltage nodal point. The pick-up arrangement P_1—P_2 C_1—C_2 serves the same purpose which is discussed in connection with Figure 1.

The tube elements are enclosed in the glass envelope E, the inside of which has a gas at very low pressure. The entire apparatus functions about the same as the scheme described in Figure 1, except that the phase of the filaments in relation to the anode may be somewhat different. In general, the filaments operate push-pull in potential and if the filament on one side is maximum negative the anode potential on the same side will be maximum positive. Conditions on the opposite side of the tube will be just the reverse. Due to the ultra high frequency at which this generator will operate, and due to the comparatively low velocity of the electrons the phase of the filaments will have to be advanced ahead of that which ordinarily obtains in lower frequency oscillators. There will be some anode to filament capacity feed-back. This would ordinarily be degenerative but it can be made to regenerate by proper adjustment of the lines L_1 and L_2 by means of slider S.

The center tap on the filament transformer secondary is grounded through a by-pass condenser. Positive or negative bias voltage may be maintained on the filaments through the center tap on the filament transformer secondary. It should be noted here that the two filament conductors on each side are arranged so that they act as one wire on each side for high frequency currents; that is, the two filament power supply conductors for one filament combine to form L_1 and the other two filament power supply conductors combine to form L_2. The portion of the shield D between the filaments and anodes A may be of mesh or perforated construction.

Having thus described my invention, what I claim is:

1. An oscillatory system comprising an electron discharge device having an anode, a cathode and a control electrode, means for causing said device to generate oscillations, a radiating circuit coupled to said electrodes, a space wave pick-up antenna spaced from said radiating circuit and picking up energy radiated from said circuit, and an unbroken, long linear transmission line comprising wires which are closely spaced to one another directly connected between said pick-up antenna and said electron discharge device for feeding energy picked up by said pick-up antenna to electrodes of said device thereby controlling the frequency of operation thereof, such line having a predetermined length greater than the length of the wave generated by said system and such as to produce frequency stability.

2. An oscillatory system comprising an electron discharge device having an output electrode, means for causing said device to generate oscillations, a radiator connected to said output electrode, an antenna spaced from said radiator and picking up energy radiated therefrom, and a long substantially radiationless transmission line comprising wires which are closely spaced to one another directly connected between said pick-up antenna and said electron discharge device for feeding to said device the energy picked up to stabilize the frequency of operation of said device, said line having a length equal to a multiple of half the length of the generated wave.

3. An oscillatory system comprising an electron discharge device having an anode, a cathode

and a control electrode, means for causing said device to generate oscillations, a linear radiator connected to said anode, a pick-up antenna, spaced from said radiator and picking up energy radiated therefrom, and a two-wire, linear, unbroken transmission line directly connected between said pick-up antenna and said control electrode for feeding back the picked up energy as frequency stabilizing energy, to said control electrode, said line being of predetermined length such as to produce maximum stability of frequency and such that the control electrode voltage is at least 180° in advance from that of the anode voltage.

4. Apparatus as claimed in the preceding claim wherein means is provided for preventing anode to control electrode feed back through the inter-electrode capacity existing between the anode and control electrode.

5. An oscillatory system comprising an electron discharge device having an anode, a cathode and a control electrode, means for causing said device to generate oscillations, a radiating antenna coupled to said anode, a pick-up antenna picking up energy radiated from said antenna, and a long linear unbroken transmission line directly connected to said cathode and extending to said pick-up antenna for applying to said cathode the energy picked up in such a way as to stabilize, due to the length of said line, the frequency of oscillations generated by said device and radiated by said radiating antenna.

6. An oscillatory system comprising a pair of anodes, a pair of cathodes, and a pair of control electrodes all within a single envelope, a radiating element coupled to said anodes, a pick-up unit picking up energy from said element and spaced therefrom, and a long transmission line a plurality of half wave lengths long coupled to said pick-up unit and said control electrodes for stabilizing the frequency of operation of said systems.

7. An oscillatory system comprising a pair of anodes and a pair of control electrodes all within a single envelope, a radiating element coupled to said anodes for radiating oscillatory energy generated by said anodes and said control electrodes, a pick-up unit spaced from said radiating antenna, and a feed back path comprising a long transmission line, a plurality of half wave lengths long at a desired operating frequency connected between said pick-up unit and said control electrodes for feeding back a portion of the radiated energy to said control electrodes whereby the frequency of oscillations generated by said system is stabilized.

8. An oscillating system comprising an electron discharge device having within an evacuated container a plurality of anodes, cathodes and control electrodes, a linear radiator connected in phase opposition to said anodes, a two-wire, linear, unbroken transmission line a plurality of half wave lengths long connected to said control electrodes, and a pick-up unit spaced from said radiator picking up energy radiated by said radiator, said pick-up unit being coupled to said transmission line in such a way as to produce standing waves thereon whereby said oscillatory system is caused to oscillate at a substantially constant frequency determined in main by the spacing between said radiating antenna and pick-up unit and the length of said transmission line.

9. High frequency apparatus comprising a hermetically sealed container, a metallic cylindrical element within said container, a cathode arranged at each end of said cylindrical element, a linear member serving as an anode arranged within said cylindrical element, means for maintaining said anode at a positive potential with respect to said cathodes, and means for maintaining said cylindrical element at a negative potential with respect to said cathodes.

10. Apparatus as claimed in the preceding claim, characterized by the fact that a high frequency circuit is connected to said cathode.

11. High frequency apparatus comprising a hermetically sealed container, a metallic substantially cylindrical element within said container, a cathode arranged externally of and at each end of said cylindrical element, a linear member serving as an anode arranged within said cylindrical element, means for maintaining said anode at a positive potential with respect to said cathodes, and means for maintaining said cylindrical element at a negative potential with respect to said cathodes.

12. High frequency apparatus comprising a hermetically sealed container, a metallic cylindrical element within said container, a cathode arranged externally of and at each end of said cylindrical element, a source of energy for heating said cathodes, and a two-wire transmission line individual to each cathode connecting each cathode to said source, a linear anode member arranged within said cylindrical element, extending outside said container and functioning to radiate energy, and an antenna spaced away from said container for collecting energy radiated by said linear member, said antenna having two arms, one arm being coupled to one transmission line and the other arm to the other transmission line whereby the collected energy is applied to said cathodes for stabilizing the frequency of oscillations produced by said high frequency apparatus.

13. Apparatus in accordance with claim 12 including a tuning element capacitively coupled to the wires of both said transmission lines for adjusting the effective length of said lines.

14. An oscillatory system comprising an electron discharge device having an output electrode, means for causing said device to generate oscillations, a radiator connected to said output electrode, an antenna parallel to said radiator and spaced therefrom for picking up energy radiated thereby, a long, substantially radiationless transmission line, a plurality of half wave lengths long at the frequency of the generated oscillations comprising wires which are closely spaced to one another connected between said pick-up antenna and said electron discharge device for feeding to said device the energy picked up to stabilize the frequency of operation of said device, and a parabolic reflector surrounding at least part of said oscillatory system for directing the energy radiated thereby toward said pick-up antenna.

15. An oscillatory system comprising an electron discharge device having an anode, cathode, and control electrode, means for causing said device to generate oscillations, a radiating circuit coupled to said electrodes, a wave pick-up antenna spaced from said radiating circuit and picking up energy radiated from said circuit, and a long, two-wire transmission line, a plurality of half wave lengths long at the frequency of the generated oscillations connected between said pick-up antenna and said oscillation generator for feeding energy by said pick-up antenna to the electrodes of said oscillation generator, there-

by controlling the frequency of operation thereof, and a strap bridging the wires of said two-wire line at the end of said line remote from said oscillation generator for short circuiting said line for radio frequency energy, said pick-up antenna comprising a pair of arms, each arm being coupled to a different wire of said line.

16. An oscillatory system comprising an electron discharge device having an anode, cathode, and control electrode, means for causing said device to generate oscillations, a radiating circuit coupled to said electrodes, a wave pick-up antenna spaced from said radiating circuit and picking up energy radiated from said circuit, and a long, two-wire transmission line, a plurality of half wave lengths long at the frequency of the generated oscillations connected between said pick-up antenna and said oscillation generator for feeding energy by said pick-up antenna to the electrodes of said oscillation generator, thereby controlling the frequency of operation thereof, and a strap bridging the wires of said two-wire line at the end of said line remote from said oscillation generator for short circuiting said line for radio frequency energy, said pick-up antenna comprising a pair of arms, each arm being coupled to a different wire of said line, and a tuning coil in each of said arms for tuning said antenna.

17. An oscillatory system comprising an electron discharge device having an anode, cathode, and control electrode, a radiating circuit coupled to said electrodes, a wave pick-up antenna spaced from said radiating circuit and picking up energy radiated from said circuit, and a long, two-wire transmission line connected between said pick-up antenna and said oscillation generator for feeding energy picked-up by said antenna to the electrodes of said oscillation generator, thereby controlling the frequency of operation thereof, and a strap bridging the wires of said two wire line at a portion of said line remote from said oscillation generator for short circuiting said line for radio frequency energy, said pick-up antenna comprising a pair of arms coupled to said line at points less than one-quarter of the length of the operating wave from said strap, each arm being coupled to a different wire of said line.

18. High frequency apparatus comprising a hermetically sealed container, a metallic cylindrical element within said container, a cathode arranged at each end of said cylindrical element, a linear member substantially one-half wave long at the operating frequency serving as an anode arranged within said cylindrical element, means for maintaining said anode at a positive potential with respect to said cathodes, and means for maintaining said cylindrical element at a negative potential with respect to said cathodes.

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