

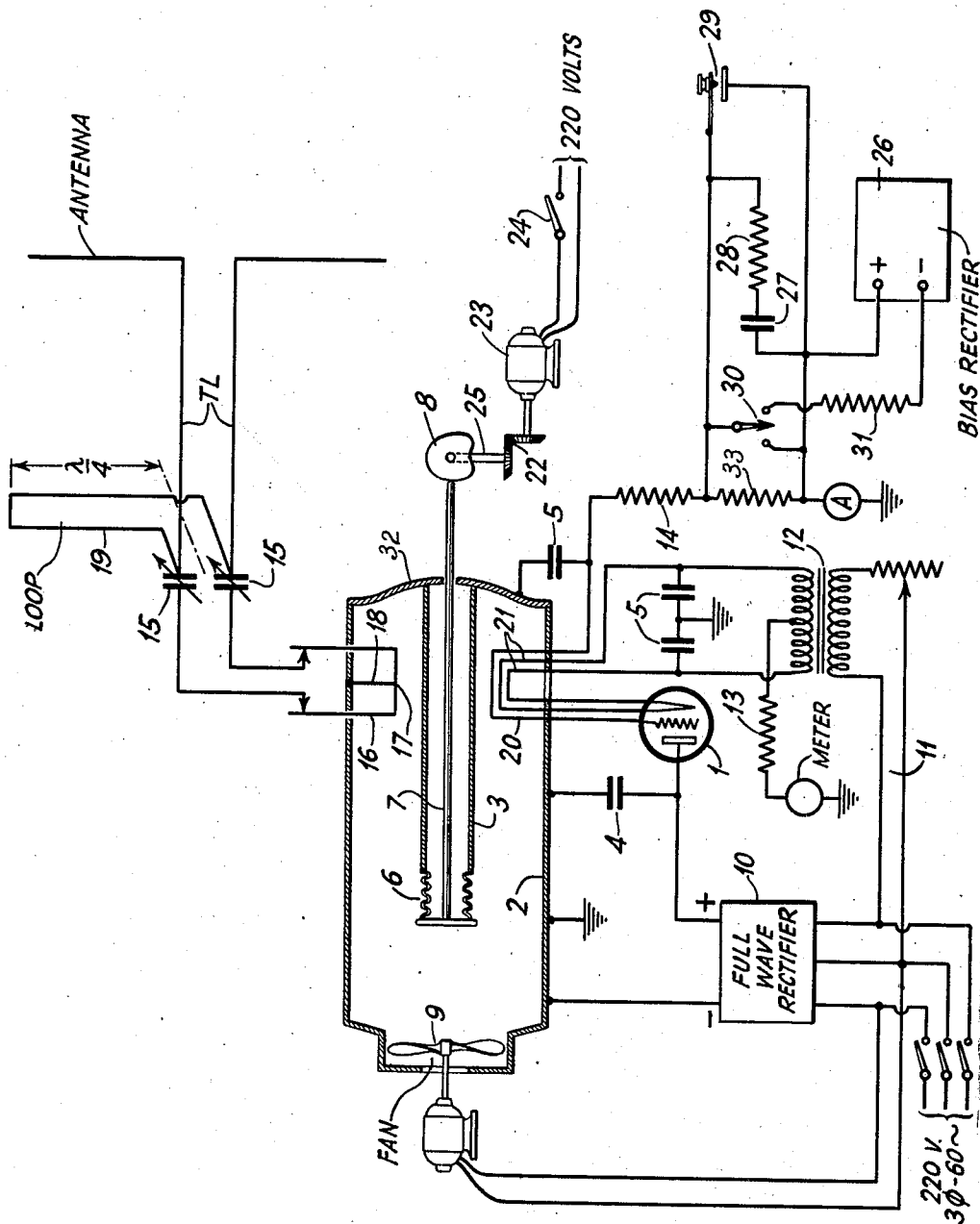
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ULTRA SHORT WAVE SYSTEM

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ULTRA SHORT WAVE SYSTEM

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This invention relates to short wave communi-
cation systems.

One of the objects of the present invention is
to provide a sharply tuned oscillation generator
system which delivers approximately constant
energy to a load throughout a range of fre-
quencies.

Another object is to provide an electron dis-
charge device oscillation generator system con-
trolled as to frequency by a tuned, low loss, con-
centric resonant line, wherein the anode of the
electron discharge device is grounded for radio
frequency energy.

A feature of the invention lies in the manner
of coupling the grid and cathode of a grounded-
anode electron discharge device oscillator to the
inner conductor of a concentric resonant fre-
quency controlling line.

Another feature resides in the use of a con-
ducting loop connected across a transmission
line, in combination with a pair of condensers
for controlling the impedance of the load circuit
over a range of frequencies. The loop is de-
signed to have an overall length equal to half the
length of the shortest wave of the range.

A further feature lies in the use of a dished
or bowed end plate of the resonant line used for
connecting the inner and outer conductors to-
gether. The design of this end plate prevents
warping or buckling by heat engendered therein
during the operation of the system, with a con-
sequent change in resonant frequency of the line.

A still further feature is the frequency sweep
arrangement used for periodically varying the
resonant frequency of the line. This particular
frequency sweep employs a cam and geared motor
for varying the effective length of the inner con-
ductor.

Other objects and features, and their advan-
tages, will appear in the following description
which is accompanied by a drawing, in which
the single figure illustrates, partly schematically
and partly in section, a high frequency trans-
mission system embodying the principles of the
present invention.

Referring to the drawing in more detail, there
is shown an oscillation generator system compris-
ing an electron discharge device 1 whose fre-
quency is controlled by a concentric resonant
line having an outer grounded conductor 2 and
an inner conductor 3. Inductively coupled to the
inner conductor are the grid and filament leads
20 and 21, respectively, of the electron dis-
charge device, and also a transmission line TL
terminating in an antenna, as shown. The anode

of electron discharge device 1 is connected to
ground for radio frequency energy through by-
pass condenser 4. Similarly, the remote ends of
the grid and filament leads are also connected to
ground for radio frequency energy through by-
pass condensers 5, 5. By-pass condensers 4 and
5, 5 are designed to have connections of practi-
cally zero length, in order to be effective at the
ultra high frequencies used in the system.

A full wave rectifier 10 is employed to provide
a positive polarizing potential to the anode of the
electron discharge device 1, while a source of
alternating current energy supplies filament heat-
ing energy over leads 11 and transformer 12.
Resistors 13 and 14 function as filament and grid
biasing resistors, respectively. Resistor 13 in the
filament ground circuit serves to maintain a posi-
tive bias potential on the filament on device 1
when anode current flows, thus protecting the
electron discharge device if oscillations cease.
Resistor 14 is a grid "leak" resistor of the order
of 6000 ohms, which supplies negative bias to the
grid of device 1 when grid current flows.

The concentric line for controlling the fre-
quency of electron discharge device 1 comprises
an inner conductor 3 and an outer conductor 2
which are directly connected together at one of
their adjacent ends by means of a dished or
bowed end plate 32. A flexible metal bellows 6 at
the open end of the inner conductor, and an Invar
rod 7 within the inner conductor 3, help to main-
tain constancy of frequency with change in tem-
perature. Since the length of the projection of
the inner conductor 3 upon the outer conductor 2
determines, generally, the resonant frequency of
the concentric line, it will be appreciated that
adjustment of the bellows 6 through rod 7 will
change the effective length of the inner conductor
and the frequency of the line. The frequency of
the transmitter may thus be adjusted to any de-
sired point in the transmitter frequency range
obtained by moving rod 7 in or out by a handle
(not shown) in order to shorten or lengthen the
metal bellows 6, which, in effect, shortens or
lengthens the inner conductor 3. Reference is
made to an article by Clarence W. Hansell en-
titled "Resonant lines for frequency control,"
published August, 1935, in "Electrical Engineer-
ing" and to United States Patent No. 2,108,895,
granted February 22, 1938, to Fred H. Kroger for
a more detailed description of the very general
principles underlying this type of resonant fre-
quency controlling line.

It has been found that the hottest part of
the resonant line is the end at which the con-

ductors 2 and 3 are closely coupled together, that is, at the shorted end of the line where the end plate 32 is located. Since the center of the end plate 32 is hottest, there is a tendency for it to warp or buckle in or out, thus tending to change the position of the inner conductor 3 to some unpredictable position with a consequent change in the resonant frequency of the line. In order to prevent such a sudden unpredictable change in frequency, due to buckling, snapping, or warping of the end plate by heat, the end plate 32 is dished or bowed either in or out, as shown. The position of conductor 3 is thus predictable and may be compensated for in the adjustment of rod 7.

If a continuous change of frequency of the transmitted oscillations over a band is desired, there is provided a frequency sweep arrangement consisting of a cam 8, a suitable gear 22 linked to the cam by a shaft 25, and a motor 23 for varying periodically the frequency of oscillations. Cam 8 is arranged to engage rod 7 for continuously changing the length of the bellows 6. Motor 23 may be stopped through switching means 24, to prevent periodic frequency variation from taking place. This method of obtaining a frequency sweep will be referred to later in connection with the arrangement used for keying the system.

A fan 9 at one end of the resonant line is used to blow air through the line for cooling purposes.

In one embodiment actually tried out in practice, for generating oscillations of a frequency of the order of 90 megacycles, the oscillator electron discharge device 1 was located within the resonant line and consisted of an evacuated device whose anode was conductively coupled to a massive hub located externally of the envelope of the device and having numerous cooling fins. The fan 9 caused a stream of air to pass not only through the resonant line but also past the fins of the air cooled tube anode to keep the anode cool and prevent excessive heating which might be detrimental to the efficient operation of the transmitter. For a more detailed description of such a device having cooling fins for the anode, reference is made to a copending Patent No. 2,176,657, granted October 17, 1939, to J. L. Finch. In the above mentioned embodiment of the invention, the connections to the by-pass condensers 4 and 5, 5 were made of minimum length and substantially zero inductance by using the ground surface (i. e., the outer surface of conductor 2 of the resonant line) as one condenser plate of each by-pass condenser. Condensers 5, 5 were actually made of special construction by widening out the filament and grid conductors 20 and 21, respectively, in the form of plates and insulating them with mica dielectric, the ground surface being the other condenser plate. As for condenser 4, the clamp holding the air cooling fins of device 1 formed one condenser plate while the ground surface of line 2 formed the other condenser plate. A Bakelite sheet comprised a direct current insulator and radio frequency dielectric for condenser 4.

Transmission line TL is shown coupled to the inner conductor 3 by way of serially connected condensers 15, 15 and loop 16, one of whose points 17 (approximately the center point) is grounded by a connection 18 which is adjustable in position over 16 for a reason described later.

In order to derive substantially constant output energy from the oscillation generator over a range of frequencies, there is provided a loop of wire 19 in shunt with the transmission line TL,

This loop 19 is arranged to have an overall length equal to half the length of the operating wave for the highest oscillating frequency in the range of frequencies which the system is desired to transmit.

In the operation of the system, the grid of electron discharge device 1 is arranged to have greater coupling to conductor 3 by the arrangement of grid lead 20 than the filament has through filament leads 21. In other words, the grid must be excited periodically at higher radio frequency potentials than, but in phase with, the filament for best oscillating conditions. Putting it still another way, the grid is driven harder than the filament.

Inasmuch as in this type of oscillator (in which the anode is grounded for radio frequencies) it is inconvenient to change the coupling of the device 1 to the resonant line or the regeneration of the device 1, as the frequency is varied by changing the effective length of the line, the amplitude of the generated oscillations will not be constant over a wide range of certain of the high frequencies, and the tendency will be for less power output at the higher frequencies and more power output at the lower frequencies in the range. This is believed to be due to the fact that there is an optimum value of coupling between vacuum tube and resonant line for a particular length of inner conductor, and as the length of this inner conductor is changed in order to change the frequency of the oscillations the coupling will also change and the voltage and current in the resonant line will fall off with change in the length of the line from the optimum value. In practice, the change in power output is not serious until certain limiting lengths for the resonant line are reached. This tendency for change in power output is overcome in the present invention by the provision of the transmission line circuit including the coil 16, condensers 15, 15 and wire loop 19. By shifting the grounding lead 18 to the proper point on coil 16, there will be obtained balanced output on the two conductors of transmission line TL. Condensers 15, 15 are adjusted to have a suitable value (determined experimentally) so that at the higher frequencies of the range the condensers will have maximum by-passing effect. Since loop of wire 19 is a half wavelength long, overall length, but one-quarter wavelength folded up, as shown, at the highest frequency of the oscillator range, this loop will have minimum shunting or shorting effect at the higher frequencies, and the high frequency energy from the system will pass to the antenna with a minimum of impedance. At the lower frequencies of the oscillator range, however, the by-pass condensers 15, 15 offer more impedance to alternating current energy passing through them, and the loop 19 has more shunting or shorting effect than at the higher frequencies; consequently the lower frequency energy will pass through the condensers 15, 15 and over the line TL with considerable impedance in the circuit. The increase in impedance at the lower frequencies of the oscillator range is approximately proportional to the decrease in frequency, whereas the amplitude of oscillations is approximately proportional to the decrease in frequency. Hence, the combined effect is that as the output voltage of the transmitter increases and decreases due to frequency decrease and increase, respectively, the load circuit impedance increases and decreases as the frequency decreases and increases, respectively,

and the energy delivered to the load (antenna) is approximately constant throughout the entire transmitter frequency range.

Although the system of the invention has been shown used with loop 19 and condensers 15, 15 for obtaining approximately constant energy in the load, it should be understood that in some cases the loop 19 and condensers 15, 15 may be dispensed with. For example, in one particular embodiment tried out successfully the loop and condensers were used at a frequency of 90 million cycles, but these were not used when the system functioned at lower frequencies, in the range between 81 and 86 million cycles. These frequencies are merely mentioned by way of illustration, and are not to be construed as limitative of the invention.

One advantage of this invention is that there is required no separate polarizing battery for the grid, except when keying is employed, since both the grid and filament obtain their proper excitation by the arrangement of the respective leads near the inner conductor 3.

In the design of the system of the invention it is very desirable to avoid resonance effects in the coupling loops 20, 21 at or near the operating frequencies, because such resonance effects will produce parasitic oscillations and certain changes in the value of coupling between the loops and the resonant line.

If it is desired to key the transmitter of the invention, i. e., transmit telegraph signals in accordance with the movement of a key, there may be provided in the manner shown in the drawing, a resistance 33 of the order of 100,000 ohms, a bias rectifier 26, a one microfarad condenser 27, a low resistance 28 of the order of 75 ohms, a switch 30, another resistor 31 of the order of 10,000 ohms, and a key 29. With such an arrangement, keying of the transmitter oscillations is effected as follows: As soon as the frequency reaches the desired point for keying, switch 24 is opened and switch 30 moved to engage its right hand terminal. Closure of switch 30 to the right will effectively insert 100,000 ohm resistor 33 in the circuit in series with the grid leak resistor 14, and at the same time connect the negative terminal of the bias rectifier 26 through the 10,000 ohm resistor 31 to the grid circuit. Condenser 27 and resistor 28 are connected in series across the contacts of key 29 to prevent destructive arcing between the key contacts during keying. The transmitter is now ready to be keyed. When the key 29 is up, current from the bias source 26 flows from the 10,000 ohm resistor 31 through the 100,000 ohm resistor 33 in the grid circuit, thereby causing a high negative voltage to appear on the grid of electron discharge device 1 so that no oscillations can start, since the vacuum tube is biased past cut-off. If the key 29 be pressed down, the 100,000 ohm resistor 33 in the grid circuit is short circuited and also the bias source 26 is shorted through the 10,000 ohm resistor 31 (resistor 31 is used to prevent completely short circuiting and damaging the bias rectifier 26). At this instant the device 1 has no bias on its grid. Consequently anode current will flow and oscillations build up. The grid is thereby excited and the flow of rectified grid current through the 6,000 ohm resistor 14 furnishes normal operating bias during the time of oscillation. Now, if the key 29 is lifted, the 100,000 ohm resistor 33 is inserted again in the circuit and the flow of grid current to ground (to the cathode) is greatly reduced by this high re-

sistance, consequently the excess grid current flows into and charges the 1 mf. condenser 27 until it reaches a potential equal to the peak grid voltage (due to excitation). When this amount of grid bias voltage is reached, the transmitter will stop oscillating when the first dip in excitation energy occurs which, for practical purposes, is almost instantly. Now, assuming that there is no fixed bias source 26, then as the charge leaks out of the 1 mf. condenser 27 through the 100,000 ohm resistor 33, the grid bias will be reduced to the point where oscillations again start only to be stopped by the charging of the 1 mf. condenser 27 due to the increased bias. This process would continue indefinitely as long as the key is up, sending out pulses of oscillations. In order to prevent this start and stop of oscillations with key up, we supply a fixed negative bias potential from source 26 through a resistor 31 (about 10,000 ohms in this case). The voltage value of this fixed bias need only be sufficient to maintain cut-off of the electron discharge device anode current, although a somewhat higher value of fixed bias is desirable.

When it is desired to use the frequency sweep arrangement employing cam 8 and motor 23, the keying is stopped and continuous oscillations are permitted by moving the switch 30 to the left. The sweep motor is started by closing switch 24. Closing switch 30 to the left disconnects the fixed bias source 26 from the grid circuit and short circuits the 100,000 ohm resistor 33 in the grid circuit to allow normal operating bias to exist on the grid during the time of oscillations.

It is to be understood that the term "ground" used in the specification and appended claims means any point or surface of zero or fixed radio frequency potential.

What is claimed is:

1. In a high frequency system, an oscillation generator for producing oscillations whose amplitude is approximately proportional to decrease in frequency, means for controlling the frequency of said oscillations and for varying the same over a desired frequency range, a transmission medium coupled to said oscillation generator whose impedance increases approximately proportionately to the decrease in frequency, and to such an extent as to compensate substantially entirely for the variation in amplitude of said generator and a load coupled to said transmission medium.

2. In a high frequency system, an electron discharge device oscillation generator for producing a range of oscillations whose amplitude increases and decreases with decrease and increase, respectively, in the frequency of oscillations generated, a utilization circuit, a transmission medium coupled between said generator and utilization circuit, said medium having the characteristic of increasing and decreasing impedance with decrease and increase, respectively, of the frequency, whereby a substantially constant output is delivered to said utilization circuit over said range, and means for periodically varying the frequency of said oscillations over a predetermined range.

3. In a high frequency system, an electron discharge device oscillation generator for producing a range of oscillations whose amplitude increases and decreases with decrease and increase, respectively, in the frequency of oscillations generated, a utilization circuit, and a transmission medium coupled between said generator and utilization circuit, said medium comprising a two conductor line, a condenser in series with each conductor

of said line of a suitable value to pass the higher frequencies of said range with minimum attenuation, and a U-shaped loop of wire in shunt with said line, the legs of said loop having a length approximately equal to one-quarter wavelength at the highest frequency of said range, whereby energy of substantially constant value is passed to said utilization circuit.

4. A system in accordance with claim 3, characterized in this that said utilization circuit is an antenna, and said loop is coupled across said two-conductor line on the side of the condensers nearest said antenna.

5. In a high frequency system, an electron discharge device oscillation generator for producing oscillations over a range of frequencies, said device having an anode, a cathode and a grid, a capacitive connection from said anode to ground for by-passing radio frequency energy from said anode, means for exciting said grid at a higher potential than and in phase with said cathode, whereby oscillations are produced whose amplitude increases approximately proportional to the decrease in frequency, a utilization circuit, and a transmission medium coupled between said generator and utilization circuit, said medium having the characteristic of increasing and decreasing impedance with decrease and increase, respectively, of the frequency, whereby a substantially constant output is delivered to said utilization circuit over a range of frequencies.

6. In a high frequency system, an electron discharge device oscillation generator for producing oscillations over a range of frequencies, said device having an anode, a cathode and a grid, a capacitive connection from said anode to ground for by-passing radio frequency energy from said anode, means for exciting said grid at a higher potential than and in phase with said cathode, whereby oscillations are produced whose amplitude increases approximately proportional to the decrease in frequency, a utilization circuit, and a transmission medium coupled between said generator and utilization circuit, said medium comprising a two-conductor line, a by-pass condenser in series with each conductor of said line of a suitable value to pass the higher frequencies of said range with minimum attenuation, and a loop of wire in shunt to said line, the length of said loop being approximately one-quarter of a wavelength at the highest frequency of said range, whereby energy of substantially constant value is passed to said utilization circuit.

7. In a high frequency system, an electron discharge device oscillation generator for producing oscillations over a range of frequencies, said device having an anode, a cathode and a grid, a capacitive connection from said anode to ground for by-passing radio frequency energy, and a frequency control circuit for said generator comprising a concentric resonant line having inner and outer conductors suitably coupled together, loops of wire extending from said grid and cathode, respectively, within said resonant line for inductively coupling to the inner conductor of said line, said loops of wire being so arranged that said grid loop is excited at a higher potential than said cathode loops.

8. In a high frequency system, an electron discharge device oscillation generator for producing oscillations over a range of frequencies, said device having an anode, a cathode and a grid, a capacitive connection from said anode to ground for by-passing radio frequency energy, a

frequency control circuit for said generator comprising a concentric resonant line having inner and outer conductors suitably coupled together, loops of wire extending from said grid and cathode, respectively, within said resonant line for inductively coupling to the inner conductor of said line, said loops of wire being so arranged that said grid loop is excited at a higher potential than said cathode loops, whereby the amplitude of oscillations produced is approximately proportional to the decrease in frequency, a utilization circuit, a two-conductor transmission line inductively coupled to said inner conductor of said resonant line at one end and coupled to said utilization circuit at its other end, a by-pass condenser in series with each conductor of said line of a suitable value to pass the higher frequencies of said range with minimum attenuation, and a loop of wire in shunt with said line, said loop being approximately one-quarter of a wavelength at the highest frequency of said range, whereby energy of substantially constant value is passed to said utilization circuit.

9. In a high frequency system, an electron discharge device oscillation generator for producing oscillations over a range of frequencies, said device having an anode, a cathode and a grid, a capacitive connection from said anode to ground for by-passing radio frequency energy, and a frequency control circuit for said generator comprising a concentric resonant line having inner and outer conductors coupled together more closely at one of their adjacent ends than at their other, means for exciting said grid in phase with but at higher radio frequency potentials than said cathode, said means comprising loops of wire located within said resonant line extending from said grid and cathode, respectively, to ground for inductively coupling said electrodes to said resonant line, a bias resistor for said cathode electrode for maintaining said cathode at a positive potential with respect to ground when oscillations cease, and a bias resistor for said grid for maintaining said grid at a negative potential with respect to the cathode when the grid current flows.

10. In a high frequency system, an electron discharge device oscillation generator for producing oscillations over a range of frequencies, said device having an anode, a cathode and a grid, a capacitive connection from said anode to ground for by-passing radio frequency energy, and a frequency control circuit for said generator comprising a concentric resonant line having inner and outer conductors suitably coupled together, loops of wire extending from said grid and cathode, respectively, within said resonant line for inductively coupling to the inner conductor of said line, said loops of wire being so arranged that said grid loop is excited at a higher potential than said cathode loops, a negative bias potential source, and means for switching in a high resistance and for connecting in said negative bias potential source to the grid circuit of said electron discharge device, there being keying means connected across said high resistance when it is desired to prepare said system for keying.

11. In a high frequency system, an electron discharge device oscillation generator for producing oscillations over a range of frequencies, said device having an anode, a cathode and a grid, a capacitive connection from said anode to ground for by-passing radio frequency energy, and a frequency control circuit for said generator

comprising a concentric resonant line having inner and outer conductors coupled together more closely at one of their adjacent ends than at their other, loops of wire extending from said grid and filament, respectively, within said resonant line for inductively coupling to the inner conductor of said line, said loops of wire being so arranged that said grid loop is excited at a higher potential than said filament loops, and keying means for producing a high negative bias on said grid to cause oscillations to cease, in accordance with the signals to be transmitted.

12. In combination, an electron discharge device oscillation generator having coupled thereto a frequency controlling circuit comprising a tuned circuit in the form of a concentric line having an inner conductor and an outer conductor, means for coupling said conductors together at one end, and means for varying the frequency of oscillations produced over a predetermined band by continuously varying the effective length of said inner conductor.

13. In a high frequency system, an electron discharge device oscillation generator for producing oscillations whose amplitude changes with change in frequency, a utilization circuit, and a transmission medium coupled between said generator and utilization circuit, said medium having the characteristic of changing its impedance to the flow of energy thereover as the frequency of the oscillations produced by said generator changes, whereby a substantially constant output is delivered to said utilization circuit, and means for periodically varying the frequency of said oscillations.

14. In a high frequency system, an electron discharge device oscillation generator for producing oscillations whose amplitude changes with change in frequency, a utilization circuit, a transmission medium coupled between said generator and utilization circuit, and a network coupled to said medium for maintaining the impedance thereof to the energy produced by said generator substantially constant, whereby substantially constant power output is delivered to said utilization circuit, and means for periodically varying the frequency of said oscillations.

15. In a high frequency system, an electron discharge device oscillation generator having coupled thereto a frequency controlling circuit comprising a tuned circuit in the form of a concentric line having an inner conductor and an outer conductor, means for coupling said conductors together at one end, a metallic bellows attached to said other end of said inner conductor, a rod located within said inner conductor, said rod being fastened at one end to said bellows and having its other end extending externally of said concentric line, and means linked to said rod for continuously lengthening and shortening said bellows for varying the effective length of said inner conductor for varying the frequency of oscillations produced over a predetermined band.

16. A system in accordance with claim 15, characterized in this that said last means comprises a cam and a motor for driving said cam at a predetermined speed.

17. In a transmitter, the combination with an oscillation generator whose output voltage increases and decreases with decrease and increase of frequency, respectively, of a load connected to said generator through a path whose impedance increases and decreases as the frequency decreases and increases respectively, whereby the energy delivered to said load is approximately constant over a range of frequencies.

18. In a high frequency system, the combination with an oscillation generator whose output voltage varies with frequency, means for periodically varying the frequency of said generator over a range of frequencies, of a load connected to said generator through a path whose impedance varies with frequency in such sense and to such an extent as to compensate substantially entirely for the variation in output voltage, whereby approximately constant energy is delivered to said load.

19. In a high frequency system, an electron discharge device oscillation generator for producing oscillations, said device having an anode, a cathode and a grid, a capacitive connection from said anode to ground for by-passing radio frequency energy, and a frequency control circuit for said generator comprising a concentric resonant line having inner and outer conductors suitably coupled together, and means for coupling said grid and cathode to said resonant line such that said grid is excited at a higher potential than, but in phase with, said cathode.

20. In a high frequency system, an electron discharge device oscillation generator for producing a range of oscillations whose amplitude increases and decreases with decrease and increase, respectively, in the frequency of oscillations generated, a utilization circuit, a transmission medium coupled between said generator and utilization circuit, said medium having the characteristic of increasing and decreasing impedance with decrease and increase, respectively, of the frequency, whereby a substantially constant output is delivered to said utilization circuit over said range, a frequency stabilizing element for said oscillation generator, and means acting on said stabilizing element for changing the frequency of the produced oscillations.

21. In a high frequency system, an electron discharge device oscillation generator for producing oscillations whose amplitude changes with change in frequency, a utilization circuit, an electrically conducting transmission medium coupled between said generator and utilization circuit, and a loop of wire connected in shunt to said transmission medium, said loop having a length approximately equal to one-quarter of a wavelength at the highest frequency to be generated, whereby a substantially constant output is delivered to said utilization circuit.

22. In a high frequency system, the combination with an oscillation generator whose output voltage varies with frequency, of a load connected to said generator through a two-wire transmission line, and a U-shaped loop having a length approximately equal to one-quarter wavelength at the highest operating frequency of said generator connected at its open ends across said line, whereby approximately constant energy is delivered to said load.

23. In a high frequency system, an electron discharge device oscillation generator for producing oscillations over a range of frequencies, said device having an anode, a cathode and a grid, a capacitive connection from said anode to ground for by-passing radio frequency energy, and a frequency control circuit for said generator comprising a concentric resonant line having inner and outer conductors suitably coupled together, and means for inductively coupling said grid and cathode to said resonant line such that said grid is excited at a higher potential than, but in phase with said cathode.

24. In a transmitter, the combination with an oscillation generator whose output voltage varies

with frequency, of a load connected to said generator through a path whose impedance varies with frequency in such sense and to such an extent as to compensate for the variation in output voltage, whereby approximately constant energy is delivered to said load, said path comprising a two-conductor transmission line having a condenser in each conductor of said line.

25. In a high frequency system, an electron discharge device oscillation generator for producing oscillations over a range of frequencies, said device having an anode, a cathode and a grid, a capacitive connection from said anode to ground for by-passing radio frequency energy, and a frequency control circuit for said generator comprising a concentric resonant line having inner and outer conductors suitably coupled together, and means for coupling said grid and cathode to

said resonant line such that said grid is excited at a higher potential than, but in phase with said cathode, and means for changing the resonant frequency of said line.

26. In a radio transmission system, an oscillation generator whose output voltage varies with frequency, means for periodically varying the frequency of said generator over a range of frequencies, an antenna, and connections from said oscillation generator to said antenna including a network whose transmission characteristics are so chosen as to compensate substantially entirely for the variation in output voltage, whereby approximately constant energy is delivered to said antenna.

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