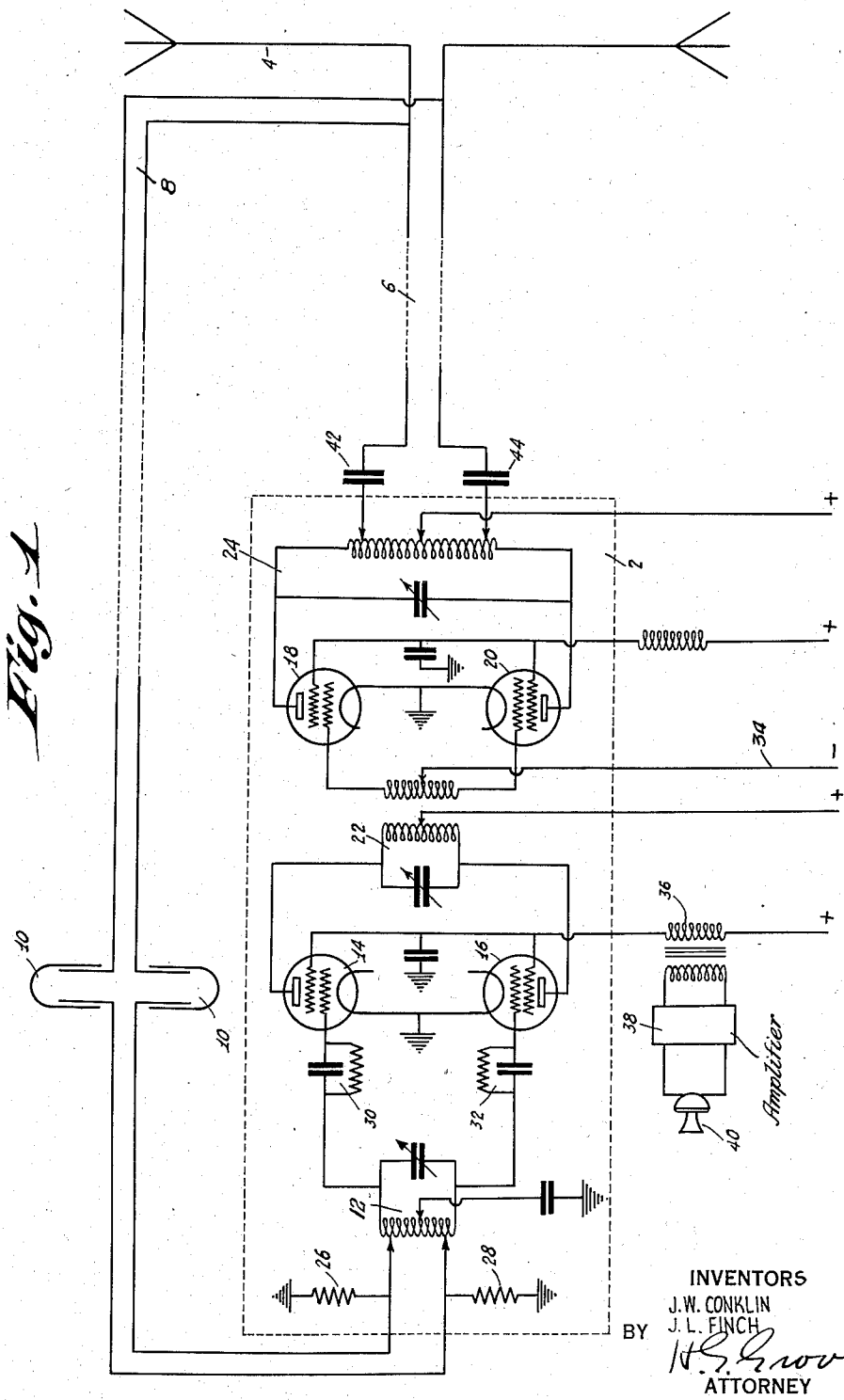
Jan. 1, 1935. J. W. CONKLIN ET AL 1,986,623

SIGNALING APPARATUS

Filed March 21, 1931 2 Sheets-Sheet 1

Fig. 1



INVENTORS
J.W. CONKLIN
J. L. FINCH

BY H. G. Grover

ATTORNEY

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Filed March 21, 1931 2 Sheets-Sheet 2

Fig. 2

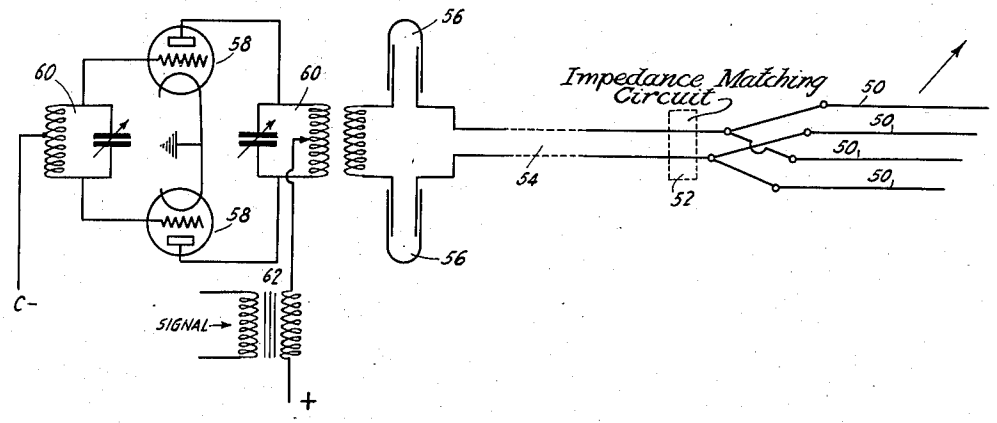
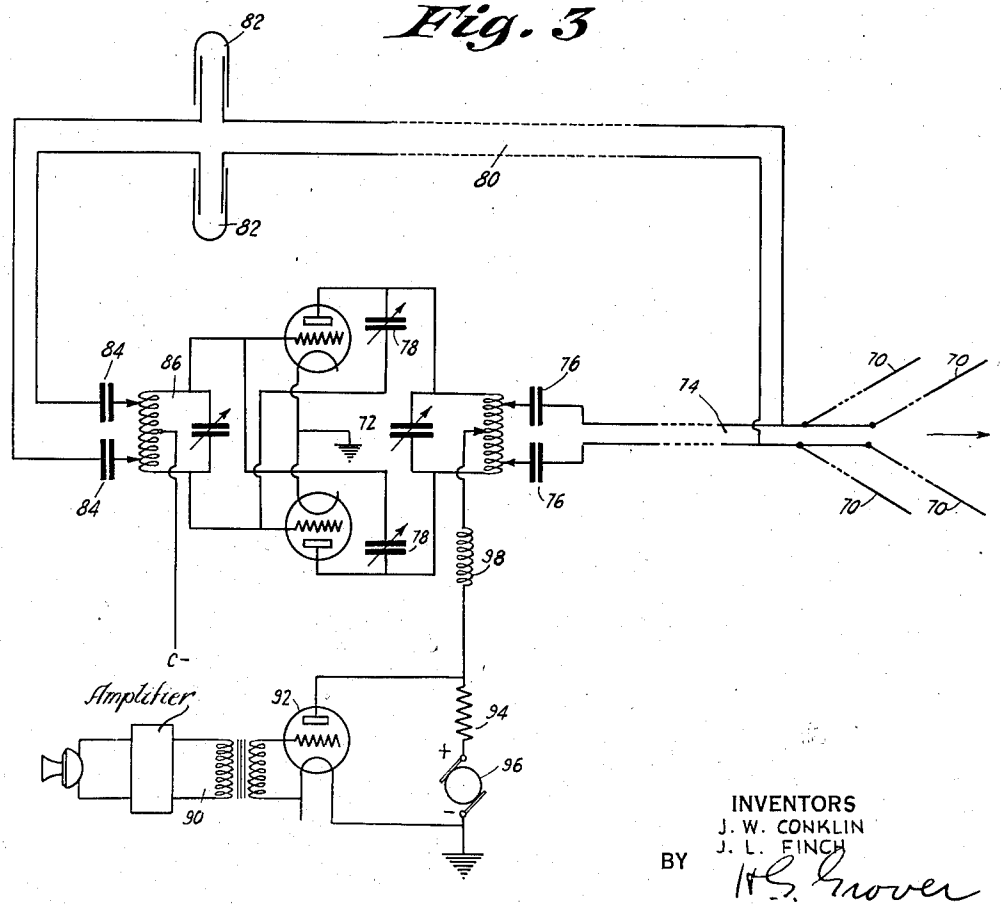


Fig. 3



INVENTORS
J. W. CONKLIN
J. L. FINCH

BY H. S. Grover

ATTORNEY

Patented Jan. 1, 1935 1,986,623

UNITED STATES PATENT OFFICE

1,986,623

SIGNALING APPARATUS

James W. Conklin, Rocky Point, and James L. Finch, Patchogue, N. Y., assignors to Radio Corporation of America, a corporation of Delaware

Application March 21, 1931, Serial No. 524,272

4 Claims. (Cl. 250—17)

This invention relates to high frequency signaling apparatus and especially to apparatus wherein the frequency of an electron discharge device oscillator is controlled and stabilized by the use of transmission lines, long, relative to the working wave length.

In general, it may be said that signaling systems and especially transmitting systems comprise an oscillation generator, means to control and stabilize the frequency of oscillations generated thereby, an antenna, and a transmission line coupling an output circuit of the generator to the antenna. Heretofore, the frequency controlling and stabilizing means have taken the form of piezo-electric crystals and their associated circuits, or intricate net-works of tuned oscillation circuits, which were costly both as to initial installation and as to maintenance. An object of the present invention is, broadly, the simplification of and reduction in cost of such apparatus; and, a further and more specific object of this invention is to utilize the transmission line of the combination referred to for frequency control and stabilization of the system.

That is, according to the present invention, the transmission line between the antenna and high frequency apparatus is used as part of a long line frequency controlling system such as described by us in our copending application on a Frequency control system, Serial Number 363,660, filed May 16, 1929; in the copending application of Clarence W. Hansell on an Oscillator, Serial Number 400,489, filed October 18, 1929; or, such as described by us in our copending application on Frequency control systems, Serial Number 511,210, filed January 26, 1931.

Systems such as described in the copending applications have been found very satisfactory for use in connection with oscillation generators of the electron discharge device type, long lines being coupled to the oscillators so that there is a shift in phase of energy on the lines with a shift in frequency materially enhanced by the length of line; for, the shift or change in phase between the input and output ends of the line is directly proportional to the number of wave lengths contained on the line. Consequently, by making the line a number of wave lengths long, there is an augmented shift in phase with a change in frequency, which shift may be used to pull the oscillator back into step at a frequency corresponding to that for which the line is the correct number of wave lengths or half wave lengths, long. Moreover, as the line can be constructed and designed to accommodate large amounts of power, it can be applied directly to the final stages of a power amplifier, thereby making the power amplifier its own generator of oscillations and eliminating the expenses incident to, and the evils concomitant with the use of a master oscillator such as a crystal oscillator and a long chain of amplifiers and frequency multipliers for building the crystal oscillator energy up to a desired frequency and value or intensity to operate the power amplifier.

The lines for frequency control, as disclosed in the copending applications, may have only traveling waves thereon in which case the lines are termed "aperiodic"; the lines may have standing waves thereon for frequency controlling stabilization and with such waves thereon they are termed "resonant"; or, the lines may have both standing and traveling waves thereon for frequency control of the oscillation generator to which it is coupled.

More specifically, in the case of an aperiodic long line frequency control system, the line is used to couple input and output circuits of an electron discharge device oscillator and is terminated at the output end of the line or the input side of the device with an impedance equal in value to the surge impedance of the line, whereby reflections with their accompanying standing waves on the line are prevented. The line is made of such a length that at a desired frequency, the potentials applied to the input circuit from the output circuit of the device are of correct phase for the production of oscillations at only the frequency for which the line contains the correct number of whole half wave lengths. The aperiodic line and its action are more fully disclosed in our copending application Serial Number 363,660, filed May 16, 1929.

In the resonant long line frequency control system, the line, coupled to the oscillator, is either short circuited or open ended so that standing waves are produced thereon. Frequency controlling action of this system may be attributed to the fact that the standing waves on the line pull the oscillator into step therewith, and, as the standing waves are determined in length by the length of the line, it is clear that with a suitably designed line, invariable in length, the frequency of oscillations generated will be maintained very constant. The action and structural organization of such a system is more fully disclosed in the copending

application of Clarence W. Hansell referred to hereinabove.

In our copending application Serial Number 511,210, filed January 26, 1931, we have described a system wherein both standing waves and traveling waves on the line are used for frequency control, the line producing a phase shift with a shift in oscillator frequency proportional to the number of waves on the line. However, in this system, in order to get a maximum phase shift in energy between the input end of the line and output end of the line, it is necessary to place a reactor at the input end of the line to introduce a 90 degree phase shift so that the line may be fed at a current maximum or voltage nodal point. Reference is made to our copending application, Serial Number 511,210, filed January 26, 1931, for a more complete description of the "combination" long line for frequency control and for a more complete description of its structure and action.

It is a further object of the present invention to utilize the transmission line coupling the antenna of a high frequency system to high frequency apparatus as part of one of the long line frequency controlling systems hereinabove referred to for stabilization and control of oscillations generated by the oscillating system or oscillator in the high frequency apparatus, whereby the entire system is materially simplified.

Moreover, certain types of directional antennæ, such as described by Nils E. Lindenblad in his copending application, Serial Number 304,445, filed Sept. 7, 1928, and Philip S. Carter in his copending application Serial Number 460,467, filed June 11, 1930, comprise conductors, long, relative to the working wave length, the conductors having standing waves thereon. It is a further object of the present invention to combine such antennæ systems with an oscillation generator and the transmission line coupling the generator and the antenna systems in order to use both the antenna and transmission line as part of a long line system for frequency controlling and stabilizing the oscillations generated by a generator in the high frequency apparatus coupled to the antenna system, thereby still further increasing the frequency constancy of the apparatus as a whole as well as simplifying still further the entire signaling system.

Although it has been attempted to define the present invention in the appended claims, it may, however, be best understood as to its structural organization and method of operation by referring to the accompanying drawings wherein,

Figure 1 illustrates a high frequency system utilizing a transmission line between the antenna and high frequency apparatus as part of an aperiodic long line frequency control system,

Figure 2 illustrates a similar system wherein the transmission line is used as part of a resonant frequency controlling scheme, and,

Figure 3 illustrates a transmission system wherein the transmission line coupling high frequency apparatus to an antenna has both standing and traveling waves thereon which are used to frequency control an oscillator of the high frequency apparatus coupled to the antenna.

Referring to Figure 1, high frequency apparatus 2 is coupled to a radiating antenna 4 through the medium of a transmission line 6 which, according to this invention, is used, as shown, to aperiodically control the frequency of oscillations generated by the high frequency system or apparatus 2. The output end of transmission line 6 not only feeds antenna 4, but through another transmission line 8, runs parallel to and supported by the same supports for line 6, feeds the tunable input circuit 12 of push-pull connected screen grid electron discharge devices 14, 16. The length of the combined lines 6 and 8 may be varied by means of the U-shaped adjustable slides 10.

By virtue of the foregoing arrangement, energy amplified by the pushpull connected amplifiers 18, 20, is fed back over lines 6, 8 to cause sustained oscillation generation at a frequency roughly determined by the tuning of the input and output circuits 12, 22 and 24 for electron discharge device 14, 16 and 18, 20, and accurately fixed by the lines 6, 8.

That is, for accurate frequency control, feed back other than that along the transmission lines is prevented by suitably shielding the circuits, and, by, as already indicated, using screen grid tubes or by suitably neutralizing the devices as disclosed in our copending application Serial Number 499,642, filed December 3, 1930.

By suitably adjusting the lengths of the lines by sliders 10 so that the lines are a suitable whole number of half wave lengths long at the desired frequency of operation, the lines 6, 8 will feed energy to the input circuit 12 at correct phase condition relative to the high frequency output potentials on the anodes of tubes 14, 16 only for a frequency corresponding to that for which the lines 6, 8 have been made a whole number of half wave lengths long.

As the lines may be a whole number of half wave lengths long for a number of frequencies, tuning of the tunable circuits 12, 22, 24 associated with the electron discharge devices to approximately the desired frequency will cause those circuits to offer high impedances to energy of other frequencies. Consequently, the entire system will oscillate only at that frequency for which the lines are a correct number of half wave lengths long and for which the tunable circuits are tuned to approximately the correct value.

In order to prevent reflections, the lines are terminated by suitable impedances in the form of resistances 26, 28 equal in value to the surge impedances of the lines. Biasing of the tubes may be accomplished by condenser and resistance arrangements such as grid leak and condenser arrangements 30, 32, or, biasing potential may be supplied, as done in connection with tubes 18, 20, through a suitable lead 34. Modulation may be introduced to the screen grids of tubes 14 and 16 by the action of modulation transformer 36 supplied from a suitable amplifier 38 and transmitter 40 with modulating potentials. This modulating arrangement may be replaced by other desirable schemes such as the one described more fully hereinafter in connection with Figure 3.

To prevent the application of anode potentials of tubes 18, 20 to the control electrodes or usual grids of tubes 14, 16, blocking condensers 42, 44 are inserted in the transmission line 6 which are made sufficiently large so that they do not introduce any appreciable phase change in currents from output circuit 24. However, should condensers 42, 44 introduce any phase

change this may readily be compensated for by a suitable adjustment of sliders 10.

By the use of transmission line 6 and line 8, an exceptionally long line may readily be had which, for frequency control offers the decided advantage that for a shift in oscillation frequency, there is a shift in phase between the input and output ends of the line proportional to the number of wave lengths contained in the line or feed back conductors. Consequently, any slight shift in frequency is accompanied by a large phase change resulting in the rapid return to the desired frequency and therefore production of oscillations of a constant, desired, predetermined frequency.

The invention described in Figure 1 may not only be used in an aperiodic frequency control system, but, the transmission line coupling high frequency apparatus and an antenna may also be used in a resonant long line frequency controlling system. Moreover, certain types of antennæ comprising conductors which are long, relative to the working wave length, having standing waves thereon, may be used in combination with the long line frequency control system to give added stability to the oscillating system.

Thus, in Figure 2 there is disclosed an antenna system comprising a number of linear conductors 50, long, relative to the working wave length, arranged in physically parallel fashion but staggered so that radiation occurs predominantly in the plane of the conductors in the direction of the arrow, making a predetermined angle with the conductors. The construction and action of this antenna are more fully described in the copending application of Nils E. Lindenblad already referred to and, therefore, need not here be gone into in greater detail.

In the normal construction of such a signaling system an impedance matching circuit 52 is inserted in the transmission line 54 but, in accordance with the present invention, this impedance matching device is omitted, the standing waves on the conductors 50 being allowed to make themselves manifest on the transmission lines 54 having therein length adjusting means in the form of U-shaped sliders 56.

As a consequence of the foregoing construction, by suitably adjusting the overall length of the antenna and transmission line, standing waves on the line will pull the pushpull connected oscillation generator 58 into step therewith, the frequency of oscillations of the oscillation generator being initially roughly or approximately adjusted to a desired value by adjustment of the tunable circuits 60 after which the action of line 54 and antenna 50 will maintain accurate frequency control.

For regenerative action, the electron discharge devices of oscillator or generator 58 are designed so as to have sufficient interelectrode capacity to get the desired feed back, or, any of the other known means in the art may be used for this purpose. Modulation may be accomplished by applying signal potentials to the anodes of oscillators 58 through the action of a modulation transformer 62.

From another aspect it may be said that the frequency controlling action of the system shown in Figure 2 is attributable to the fact that there is a phase shift between the incoming and reflected waves on the line 54 of a value proportional to the number of waves contained on the antenna and transmission line. This phase shift between the incoming and reflected waves produces a desired stabilizing effect and, by using the transmission line and antenna for this purpose, a high degree of frequency stability may be obtained without the addition of apparatus other than that formerly used and in fact omitting certain apparatus heretofore required, namely, impedance matching device 52.

A system utilizing the present invention in connection with a long line frequency control system wherein both standing and traveling waves on a long transmission line are used for frequency control is shown in Figure 3. Here, an antenna system comprising a plurality of conductors 70, long, relative to the working wave length and having standing waves thereon, are arranged at an angle such that the radiation occurs predominantly in the plane of the conductors and along the bisector of the angle formed by the conductors. The direction of maximum radiation is indicated by the arrow. The antenna is coupled to an oscillator 72 through a transmission line 74 and small reactors, here in the form of condensers 76, introduce a 90 degree phase change in energy from the output circuit of oscillator 72 fed into the line 74.

Modulating potentials from a suitable source 90 may be used, as shown, to control the flow of current to electron discharge device 92 in series with the output circuit on which there is placed a resistance 94 and source of unidirectional potential 96. Variation in current flow through the resistance 94 will cause potential variations at the upper end thereof next to radio frequency choke coil 98 thereby varying the plate potential on the anodes of the push-pull connected system 72 shown, and in turn causing modulation of the output thereof. This modulating scheme, of course, may be substituted in and for the arrangement described in connection with Figure 1 if desired.

After the electron discharge devices of oscillator 72 are suitably neutralized by adjustment of neutralizing condenser 78, feed back is established through transmission line 74 and transmission line 80 having U-shaped sliders 82 therein for length adjustment through large condensers 84 to the tunable input circuit 86.

Condensers 84 should be chosen sufficiently large so that there is no appreciable change in energy fed back and are added for the purpose of preventing application of anode potentials to the grids of the devices forming oscillator 72 should one of the relatively small condensers 76 break down.

It is to be noted that the line 80 is not terminated by a correct surge impedance to prevent reflections. Consequently, standing waves are set up on transmission line 80 which are enhanced by the standing waves on the antenna conductors 70. Oscillations will ensue at a frequency roughly determined by the tuning of the input and output circuits and accurately determined by the length of transmission lines 74 and 80.

In order to get a maximum phase shift between the input and output ends of the transmission lines forming the feed back circuit, it is desirable to feed transmission lines 74 at a voltage nodal or current maximum point. However, this will necessitate a line a whole number of half wave lengths long plus or minus a quarter of a wave length as disclosed more fully in our copending application, Serial Number 511,210, filed January 26, 1931. Consequently, to

compensate for the undesired quarter wave length of line, reactors 76 in the form of small condensers have been inserted which produce a 90 degree shift in energy fed into the lines. Therefore, at a desired frequency, the phase relationship of input and output potentials for the electron discharge devices forming the oscillator 72 will be correct and, in the event of a shift in oscillation frequency, there will be a shift in phase of energy fed back over the lines to the input side of the oscillator increased by an amount directly proportional to the number of half wave lengths on the transmission lines. This shift in phase will counteract a change in frequency bringing the oscillator back to that frequency for which the line is the correct number of half wave lengths long.

Here again in this system, for frequency control, apparatus that would of necessity be required is used, and, the line 80 which may be made to parallel transmission line 74 at a relatively minor cost, is the only addition required, thereby resulting in a system extremely stable in frequency and inexpensive.

As will be apparent to those skilled in the art, many minor changes in this invention may be made. Consequently, the invention is not to be limited by the modifications described but solely by the scope of the appended claims.

Having thus described our invention, what we claim is:

1. In high frequency signaling apparatus, an electron discharge device oscillator, an antenna comprising a plurality of conductors, long, relative to the operating wave length, a transmission line, many half wave lengths long connected between said oscillator and said antenna for feeding oscillatory energy from said oscillator to said antenna, the overall length of said antenna and transmission line being adjusted so that many standing waves at the desired operating frequency are set up thereon whereby said standing waves upon said antenna and transmission line control and stabilize the frequency of oscillation of said electron discharge device oscillator.

2. In signaling apparatus utilizing alternating electrical currents, the combination of high frequency apparatus including an oscillation generator, an antenna, a transmission line coupling the antenna and said high frequency apparatus, a conductor having uniformly distributed inductance and capacity connected from the antenna end of said line to said oscillation generator, an impedance equal in value to the surge impedance of said conductor connecting the oscillation generator end of said line to ground, whereby energy fed from said transmission line to said conductor and back to said oscillation generator maintains the frequency of operation of said oscillation generator substantially constant.

3. In signaling apparatus utilizing undulatory electrical currents, the combination of high frequency apparatus including a multi-electrode oscillation generator, a tuned circuit tuned approximately to a desired frequency of operation coupled to the output electrodes of said generator, an antenna, and a transmission line coupling said antenna to said tuned output circuit, said transmission line being adjusted in length so as to be substantially a whole number of half wavelengths long at a desired operating frequency and acting to frequency control and stabilize the frequency of oscillations generated by said oscillation generator.

4. In apparatus for high frequency electrical currents, a pair of pushpull connected electron discharge devices, a tuned circuit connected to the output electrodes of said devices, means for establishing feedback from the output circuit of said device to the input circuit of said devices whereby oscillations are generated at a frequency corresponding to approximately the tuned frequency of said circuit, an antenna, and, a transmission line comprising a pair of conductors arranged so as to be substantially radiationless coupled to said tuned output circuit and said antenna, said transmission line being adjusted in effective electrical length so as to frequency control and stabilize the frequency of oscillations of said pushpull connected devices at a predetermined desired operating frequency.

JAMES W. CONKLIN.
JAMES L. FINCH.