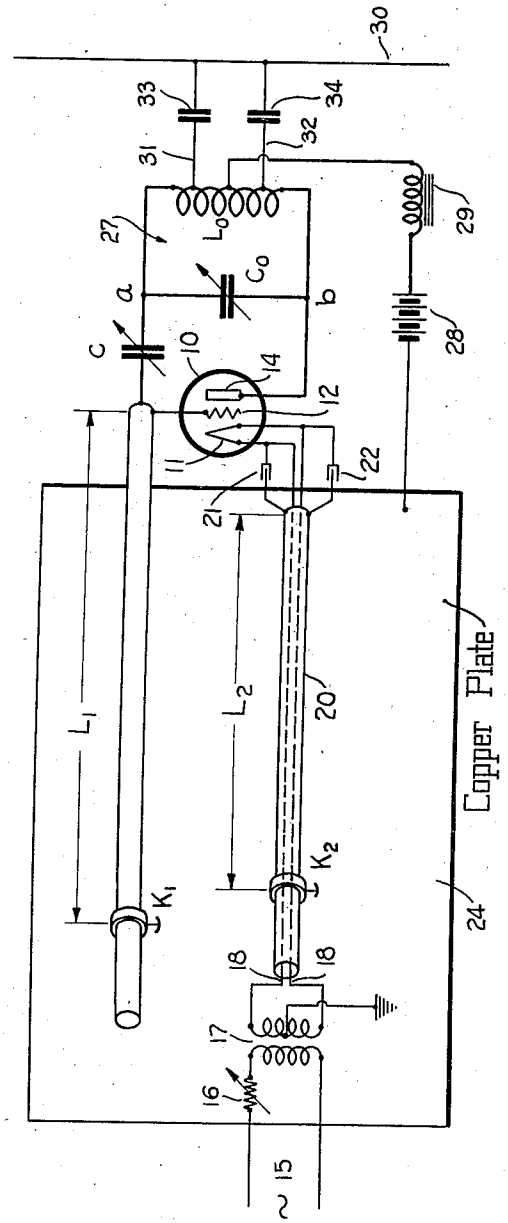
Jan. 26, 1937. F. A. KOLSTER ET AL 2,068,990

HIGH FREQUENCY OSCILLATION GENERATOR

Filed June 1, 1934



INVENTORS
Frederick A. Kolster
Paul F. Byrne

BY R. C. Hopgood
ATTORNEY

Patented Jan. 26, 1937 2,068,990

UNITED STATES PATENT OFFICE

2,068,990

HIGH FREQUENCY OSCILLATION GENERATOR

Frederick A. Kolster, New York, N. Y., and Paul F. Byrne, West Caldwell, N. J., assignors to Federal Telegraph Company, Newark, N. J., a corporation of California

Application June 1, 1934, Serial No. 728,552

8 Claims. (Cl. 250—36)

This invention relates to oscillation generators, and more particularly to a vacuum oscillating circuit for generating high frequency waves.

An object of this invention is to provide an oscillation generator for generating high frequency waves, the frequency and amplitude of which may be readily controlled, and in which a high degree of frequency stability is attained.

Another object of the invention is the provision of an oscillation generator system of the vacuum tube type wherein the tank or flywheel is so coupled to the vacuum tube that the frequency of the system as a whole is determined by and very closely approximates the frequency of the tank or flywheel circuit.

In accomplishing such objects of the invention, the tank circuit capacitance is made high relative to the inductance thereof and the ohmic resistance thereof is very low. The circuits external to the tank circuit which might affect the frequency of the system as a whole are made capacitatively reactive.

The capacitance of such external circuits is also made very low as compared with the effective capacitance in the tank circuit. Therefore, the effective capacitance of the tank circuit for all practical purposes is the capacitance which, with the tank circuit inductance, determines the frequency of the system as a whole; and such external capacitance being comparatively low has little effect in causing the frequency of the system as a whole to differ from the frequency of the tank circuit. Furthermore, the frequency of the tank circuit and of the system as a whole is not appreciably affected by any variation in such external capacitance. Consequently, the frequency stability of the system is very high.

The invention is of particular value in connection with oscillation generators for generating radio waves of extremely high frequency, such as the type illustrated in U. S. Patent No. 1,828,706 granted October 20, 1931 to Kolster and Kruesi, wherein, while keeping the required values of reactance in the several circuits, spurious oscillations have sometimes been encountered due to the difficulty experienced in obtaining symmetry in the several circuits.

This condition results in the loss of efficiency of the effectiveness of operation of the generator, which loss increases as the frequency of the generated oscillations increases, due to the decrease in capacity reactance between the cathode and anode of the tube; hence, this condition limits the frequency of the generated oscillations. The present invention overcomes these difficulties.

In accordance with a feature of the invention, the tank circuit is connected with its condenser across grid and anode of the vacuum tube and the source of anode current is fed thereto through the tank circuit inductance to the electrical midpoint of which said source is connected. The anode cathode and the grid cathode circuits are substantially electrically equal for the high frequency at which the apparatus operates. The circuits of the oscillation generator system are, therefore, maintained in symmetrical relation so that improved operation results and the difficulties heretofore experienced are eliminated.

The invention, therefore, makes it possible to generate efficiently high frequencies of the order of one to five meters and maintain the generated frequency constant within very narrow limits, provided the temperature of the apparatus is suitably controlled.

These results are accomplished with a minimum amount of apparatus, for such frequencies of relatively great amplitudes are generated directly without the use of frequency multiplying equipment intermediate the initial generator and the load. If greater power is required this may be obtained by providing a stage or stages of amplification which, of course, would also serve to isolate the generator from the load and decrease the reactive effect upon the generator.

Between the cathode of an oscillation generator tube and the ground, or other neutral surface, there may be provided a circuit that raises the radio frequency cathode potential above ground potential. This circuit may consist of a tubular shield which encloses the cathode supply leads and is capacitatively connected to either one or both sides of these supply leads at the end adjacent the tube and directly connected to ground by means of a connection slidable along the tubular shield. By means of this adjustable connection a desired amount of impedance may be connected in series with the anode to cathode capacity and ground to balance an impedance between the grid and ground. In this way symmetry is obtained in the oscillating circuit, while maintaining the required values of reactance.

The invention is illustrated as applied to the general type of oscillation generator, as shown in U. S. Patent No. 1,828,706 to Kolster and Kruesi. As shown in the drawing, the oscillation generator comprises a three-electrode vacuum tube 10 having a cathode 11, a grid 12 and an anode 14 suitably connected in circuits as will hereinafter be described, whereby high frequency oscillations are produced.

The cathode is heated by alternating current from a source 15 supplied through a transformer 17 and leads 18 connecting the terminals of the transformer secondary to the cathode terminals. A variable resistance 16 is connected in series with the transformer primary, while the center point of the transformer secondary is grounded for balancing purposes. Instead of heating the cathode by alternating current, a source of direct current may be employed.

Between the grid 12 and the anode 14 is connected a tank, flywheel or tunable frequency determining circuit 27, comprising a variable condenser C_0 and an inductance L_0, which tank circuit for very high frequencies, such as those having wave-lengths of from one to five meters, may take the form disclosed in copending application Ser. No. 637,564, filed October 12, 1932 by Frederick A. Kolster. A blocking condenser C, connected between the terminal or point *a* of the tank circuit and the grid 12, is variable for adjusting the grid excitation.

To the grid 12 is connected a conductor L_1 which may take the form of a solid or tubular rod having distributed inductance and distributed capacity. The length of this conductor may be adjusted by a slidable contact K_1 grounded to the ground plate 24 so as to give the desired impedance between the grid 12 and ground plate.

The terminal or point *b* of the tank circuit is connected directly to the anode 14 by a short lead. The high frequency potential of the cathode 11 may be maintained above ground potential by means of the conductor L_2 which has distributed inductance and distributed capacity and which may take the form of a tube enclosing the cathode supply conductor 18. This tubular conductor L_2 has a high frequency connection to the cathode 11 through condensers 21, 22. The length of conductor L_2 may be varied by the slidable contact K_2 which is connected to the ground plate. Adjusting the length of this conductor by the slidable contact provides for the desired impedance between the cathode and the ground plate.

The usual space current source 28 is connected through a high frequency choke coil 29 to a point in the inductance L_0, which is preferably the electrical center of the tank circuit 27. Thus anode voltage is connected to the tank circuit at a point of minimum potential to ground.

Energy from the tank circuit 27 is fed to an antenna 30, conductors 31 and 32 forming a transmission line which may contain protecting condensers 33 and 34. If greater power of the generated oscillations is desired, an amplifier or amplifiers may be interposed between the tank circuit 27 and the transmission line 31, 32. Such an amplifier would serve to isolate the generator from the load, as is well known.

The total impedance of the negatively reacting path from the tank circuit connection *a* through condenser C to the point K_1 on the neutral surface, or ground plate 24, may be made substantially equal to, or to have, the desired relation with respect to the total impedance of the negatively reacting path from the tank circuit connection *b* through the capacity existing between anode and cathode to the point K_2 on the neutral surface, or ground plate. It will be noted, further, that the point of connection of the anode potential supply is at the electrical center of the tank circuit 27, thus making the entire system electrically symmetrical with respect to the neutral surface or ground plate. Either or both of the conductors L_1 and L_2, which form the desired impedance by virtue of the distributed inductances and capacities and hence by virtue of their length, may be replaced by equivalent adjustable circuits of lump inductance and lumped capacity. However, at very high frequencies, such as those having wavelengths not greater than three or four meters, the required impedances of these elements of the system are more easily obtained by conductors, such as L_1, L_2.

The total equivalent capacity made up of the capacity of the path between the point *a* and the ground plate 24 in series with the equivalent capacity formed by the path between point *b* and ground plate 24, should be small in comparison with the capacity of the tank circuit condenser C_0 so as to reduce the effect of the series capacity upon the tank circuit, whereby the frequency of the entire system is maintained within very narrow limits of the frequency of the tank circuit itself. Thus, the tank circuit itself is the predominant factor and, in fact, substantially the sole factor in determining the frequency of the entire system since the capacity external to the tank circuit has but slight effect thereon.

Furthermore, in order that the tank circuit 27 may be the determining factor for the frequency of the entire system, it is important that the ratio of the inductance to the product of the square of the resistance and the capacity be high. As explained above it is important that the capacity of the tank circuit be large as compared to the capacity external thereto, so that, as in the present instance, said high ratio is obtained by making the resistance of the tank circuit of especially low value. Thus, the Q of the tank circuit is maintained at a very high value thereby greatly increasing the flywheel effect of the tank circuit. Q is equal to

$$\sqrt{\frac{L}{R^2C}}$$

where L is the inductance, R the ohmic resistance, and C the capacity of the tank circuit. In order to obtain a tank circuit having such characteristics, the construction disclosed in the aforesaid copending application is employed. Thus, when employing a tank circuit according to Fig. 2 of said copending application, suitable for use in a system for generating a frequency of approximately 60 megacycles wherein the copper tube or inductance element of the tank circuit is 8¼" long and 3" in diameter, and wherein the outer and inner diameters of the capacity flanges (condenser plates) are, respectively, 19¼" and 15", the Q value of 3000 is obtained. The high value of Q thus obtained is by virtue of the low ohmic resistance of the tank circuit which, in the above case, is approximately .015 ohm, the Q value being high notwithstanding the fact that the frequency ratio of the circuit is low. Further data of this general character will be found in "Q. S. T." for May, 1934, pp. 69 and 70, wherein appears an article entitled "High-Q tank circuits for ultra-high frequencies", by Frederick A. Kolster.

In the example given above, the effective capacity of the two paths *a*,K_1 and *b*,K_2 in series is very small, being only about one-hundredth of that of the tank circuit. It should be noted that the effective capacity of the tank circuit includes not only condenser C_0 but also the capacity in the tube between grid and anode which is in parallel therewith. The wave length of the fre-

quency of the system as a whole is within one-half of one percent of the frequency of the tank circuit.

It has been found possible to realize substantially the same beneficial results at high frequencies within the range mentioned by employing tank circuits having a Q of 1000, but it is not advisable in oscillation generator systems to employ a tank circuit having a Q which is very much less than 1000.

What is claimed is:

1. An oscillation generator comprising a vacuum tube having cathode, grid and anode, a tank circuit including an inductance and a condenser, one of which is variable, connected across the grid and anode, a grounded source of anode potential connected to the midpoint of said inductance, two parallel high frequency paths to ground from said midpoint, one of said paths including a portion of said inductance and the space current path from said anode to said cathode and an impedance external to said vacuum tube and the other of said parallel paths being external to said vacuum tube and including another portion of said inductance, an impedance element in said other parallel path, and means in one of said parallel paths for causing the impedance thereof to equal the impedance of the other of said paths.

2. An oscillation generator comprising a vacuum tube having cathode, grid and anode, a closed frequency determining circuit containing an inductance and a condenser, means connecting the terminals of said condenser to said grid and said anode, a grounded source of anode potential connected to the midpoint of said inductance, two parallel high frequency paths to ground from said midpoint, one of said paths including a portion of said inductance and the space current path from said anode to said cathode and an impedance external to said vacuum tube and the other of said parallel paths being external to said vacuum tube and including another portion of said inductance, an impedance element in said other parallel path, and means in one of said parallel paths for causing the impedance thereof to equal the impedance of the other of said paths.

3. An oscillation generator comprising a vacuum tube having cathode, grid and anode, a tank circuit including an inductance and a condenser, one of which is variable, connected across the grid and anode, a grounded source of anode potential connected to the midpoint of said inductance, two parallel high frequency paths to ground from said midpoint, one of said paths including a portion of said inductance and the space current path from said anode to said cathode and an impedance external to said vacuum tube and the other of said parallel paths being external to said vacuum tube and including another portion of said inductance, an impedance element having distributed capacity and distributed inductance in said other parallel path, and means in one of said parallel paths for causing the impedance thereof to equal the impedance of the other of said paths.

4. An oscillation generator comprising a vacuum tube having cathode, grid and anode, a tank circuit including an inductance and a condenser, one of which is variable, connected across the grid and anode, a grounded source of anode potential connected to the midpoint of said inductance, two parallel high frequency paths to ground from said midpoint, one of said paths including a portion of said inductance and the space current path from said anode to said cathode and an impedance external to said vacuum tube and the other of said parallel paths being external to said vacuum tube and including another portion of said inductance, an impedance element in said other parallel path, and means in one of said parallel paths for causing the impedance thereof to equal the impedance of the other of said paths, both paths including distributed capacity and distributed inductance with means for varying the amount included in each path.

5. An oscillation generator comprising a vacuum tube having cathode, grid and anode, a tank or flywheel having the terminals of the condenser thereof connected across said grid and anode, a high frequency path of negative reactance connected from one side of said tank circuit to ground or a neutral point and including the anode-cathode path in said tube, another high frequency path of negative reactance from the other side of said tank circuit to said ground or neutral point, said paths being of substantially equal impedance and the capacity of the tank circuit condenser being of the order of one hundred times the value the effective capacity of said paths in series, and the Q of said tank circuit having a minimum value of the order of one thousand, where Q is defined as

$$\sqrt{\frac{L}{R^2C}}$$

L being the inductance, R the resistance, and C the capacity of said tank circuit.

6. An oscillation generator comprising a vacuum tube having cathode, grid and anode, a tank or flywheel circut having the terminals of the condenser thereof connected across said grid and anode, a high frequency path of negative reactance connected from one side of said tank circuit to ground or a neutral point and including the anode-cathode path in said tube, another high frequency path of negative reactance from the other side of said tank circuit to said ground or neutral point, said paths being of substantially equal impedance and the effective capacity of the tank circuit being approximately one hundred times that of said paths in series.

7. An oscillation generator comprising a vacuum tube having cathode, grid and anode, a tank or flywheel having the terminals of the condenser thereof connected across said grid and anode, a high frequency path of negative reactance connected from one side of said tank circuit to ground or a neutral point and including the anode-cathode path in said tube, another high frequency path of negative reactance from the other side of said tank circuit to said ground or neutral point, said paths being of substantially equal impedance and the effective capacity of the tank circuit being approximately one hundred times that of said paths in series, and the Q of the tank circuit having a minimum value of the order of 1000, where Q is defined as

$$\sqrt{\frac{L}{R^2C}}$$

L being the inductance, R the resistance, and C the capacity of said tank circuit.

8. An oscillation generator comprising a vacuum tube having cathode, grid and anode, a tank circuit including an inductance and a condenser, one of which is variable, connected across the

grid and anode, a grounded source of anode potential connected to the mid-point of said inductance, a high frequency path of negative reactance connected between the grid and the cathode of said tube, said path being grounded at such a point therein as to form two parallel paths of equal impedance from the mid-point of said inductance, and the capacitance including the inter-electrode capacity of said tube and said negative reactance path being of the order of one hundredth of that of the tank circuit condenser with which it is effectively in parallel.

FREDERICK A. KOLSTER.
PAUL F. BYRNE.