June 30, 1942. F. E. SUMMERS 2,288,214

RADIO SYSTEM

Original Filed Jan. 17, 1934

Fig. 1.

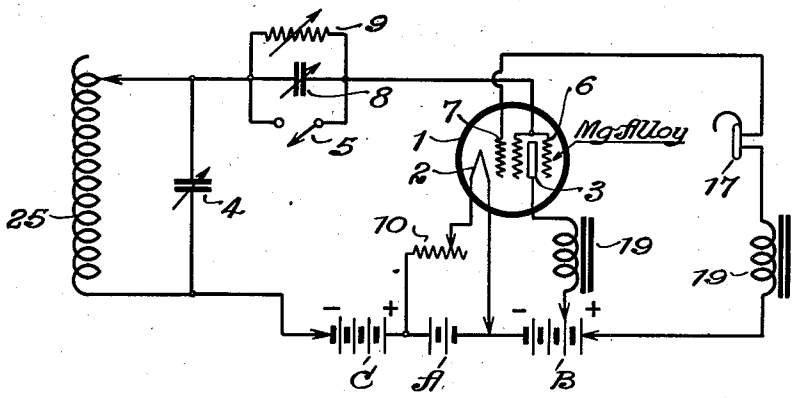
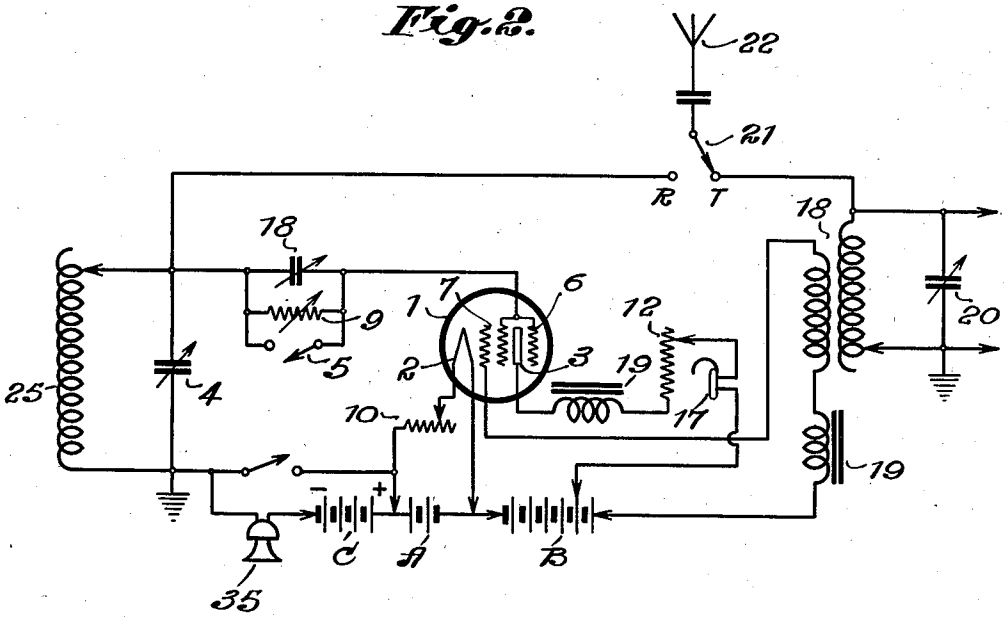



Fig. 2.




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Patented June 30, 1942

2,288,214

# UNITED STATES PATENT OFFICE

2,288,214

## RADIO SYSTEM

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Continuation of application Serial No. 706,980, January 17, 1934. This application June 26, 1939, Serial No. 281,285

1 Claim. (Cl. 250—13)

My invention relates to the generation of high frequency pulsations or oscillations to be used in connection with the transmission or reception of signals, either through the natural media or through a metallic circuit, and particularly relates to the production of high frequency pulsations or oscillations, or both, of desired characteristics by means of circuits including vacuum tubes of three or four or more electrode types.

In present circuits using such vacuum tubes for generating high frequency oscillations, brought about by bringing the circuit into the so called singing or howling condition, it is necessary to have a coupling or feed back externally from the output circuit to the input circuit of a vacuum tube. My invention provides means whereby I have obtained violent radio and/or audio frequency amplification or oscillation without using said external coupling or feed back connections conventionally associated with said vacuum tube circuits. I have also provided means to produce efficient oscillations without using the circuit known as the Dynatron System, which uses a single inductance in the anode or plate circuit. In the fundamental operation of the system that I have used, the frequency is determined mainly by the positive voltage and amperage relation of inner grid, outer grid and anode electrodes, and conduction and internal capacity between the tube elements, and inductance of secondary winding (25).

My invention does not use the well-known inductive or capacative feed back connections from the anode circuit to the input circuit. But I have discovered methods of generating high frequency oscillations or pulsations whereby a far different mode of operation is involved. My invention is specially adapted to generating very efficient ultra short waves below ten meters.

The primary object of my invention is to provide novel means whereby radio-frequency oscillations or pulsations are generated, which may be used wherever it is desirable to apply high frequency oscillations or pulsations.

Another object is to provide means whereby a noninductive variable resistance is placed serially in the untuned plate circuit, to control the characteristics of the system by bringing it to the oscillatory, slightly oscillatory, very near oscillatory, or in the non-oscillatory condition, according to the use to which this system is to be used. My invention is very efficient when used for super-regeneration.

With these and other objects of my invention in view, which will become apparent as the disclosure of this application or specification proceeds, with and in reference to the accompanying drawing, my invention resides in the novel construction, proportion and relative arrangement of apparatus and circuits as herein specified and claimed.

My invention will be better understood by reference to the following specification and accompanying drawing in which Figure 1, shows a simplified form of my invention for generating high frequency pulsations or oscillations for any desired purpose; and Figure 2 is similar to Figure 1, and shows one form of my invention applied to a combined transmitting and receiving unit using a single tube.

This application is a continuation of my application Serial No. 706,980 filed January 17, 1934, a continuation-in-part of my application Serial No. 568,066 filed October 10, 1931 and a continuation-in-part of my application Serial No. 423,737 filed January 27, 1930, Patent No. 2,267,053.

In Figure 1, I show one modification of my invention which includes a screen grid tube 1, of the four electrode type, having a single tuned input circuit having the cathode 2, inductance 25, and the grid electrode 6, serially connected therein, said circuit being tuned, or tunable, by the variable condenser 4 or 8, said condenser 4 being shunted across the inductance 25, and the variable condenser 8 being connected serially in the input grid circuit. It is preferable that the outer grid 6, be composed of magnesium, a magnesium alloy (such as magnesium and copper, magnesium and zinc, Mg & Ni, magnesium and iron) or an electrode substantially coated with a magnesium alloy, or magnesium or the equivalents of magnesium. This is more fully described and claimed in my application Serial No. 746,396 filed Oct. 1, 1934 which has issued on Nov. 4, 1941 as Patent No. 2,261,607. The plate 3 of vacuum tube 1 is connected to the positive side of the B battery, and is non-tunable. The inner grid 7 of vacuum tube 1 is connected through the telephone receivers 17, to the positive side of the B battery and is also non-tunable. It will be noted that there is no inductive or capacative feed back outside of the tube 1, to the control or input grid 6. With proper voltage relation and the elements shown in the circuits the frequency corresponds to the inductance of coil 25, the capacity of condenser 8, the capacity of condenser 4, and the inter-tube capacity of the tube elements. However, if switch 5 is closed then the frequency is determined mainly

by voltage relation, and conductivity and capacity of tube elements, as well as inherent capacity and ohmic resistance of coil **25**, which acts somewhat as a choke coil when my invention is used in this form. The frequencies generated by this method are of the order of 60 millions up to many billions per second in Figure 6 of this application. In many modifications of my invention it is well known that the signals in the plate circuit and in the inner grid circuit operate 180 degrees out of phase, by this I mean when the signals reach their maximum in the plate circuit, the pulsations or signals in the inner grid circuit reach their minimum, and vice versa.

The non-inductive grid leak or resistance **9** is shunted across the grid condenser **8**. Said condenser **8** is connected serially in the outer grid, or control electrode circuit. The correct adjustment of the capacity of condenser **8** and the resistance of element **9**, is very important for maximum efficiency of operation in many modifications. The capacity of condenser **8** passes the radio frequency current around said resistance **9**, to the outer control grid **6**, while the variable non-inductive resistance controls the amount of positive or negative voltage impressed upon the control electrode **6**, as well as the amperage of said source of electrical energy. The necessary adjustment will vary of course with the type of tubes used, and whether a positive or negative charge is used on the control grid **6**. Radio tubes having cathodes that have high electron emission power, such as oxide coated cathodes, are preferred.

The source of current C serves to impart a negative charge to the control electrode **6**. This may be from a fraction of a volt up to 45 volts or more depending on the tubes used and the result and use desired. In some forms of my invention, when switch **5** was open, I used no C source of current at all. A high negative voltage is mainly used where switch **5** is closed, and an alloy grid **6** of magnesium is used. With a magnesium alloy, grid **6**, the necessary voltage required is greatly reduced. When used as a conduction oscillator as when switch **5** is closed, then the voltage relation mainly determines the frequency generated, which are very high being in the higher end of the ultra frequencies.

In some forms my invention it is preferably to use a positive bias on the control grid **6**, as for example, when said grid is coated with a cold electron emitting material, for it is obvious a positive bias or space charge decreases the input impedance of a tube between the control grid and the cathode in conventional tubes having non-electron emitting grids. However, according to this form of my invention where a cold electron emitting control grid is used with a positive bias, the secondary electrons emitted by said control grid inherently increases the impedance, as the electrons emitted from the control grid balance or partly balance the electrons emitted by the cathode which varies accordingly with the current in the input circuit.

My preferred form of circuit functioning as a generator of oscillations is shown in Figure 1 which is adapted to generate powerful oscillations of any frequency, especially the short frequencies between 100 and 10 meters, and the ultra short frequencies between 10 and fractional meters, when switch **5** is open.

When switch **5** is closed and the control electrode **6**, is used with a negative voltage, the frequency is determined by the capacity and ohmic resistance of the circuits and tube elements used, and not by inductance. This is very efficient for fractional meter oscillations and ultra short oscillations.

When switch **5** is opened or closed the inductance **25** changes the direct current charge on the grid **6**, by self inductance to oscillations, which in turn affects the current going from the cathode **2** to the anode **3** or grid **7**, producing sustained oscillations when proper positive voltage is used on grid **7** and grid **6** is properly biased.

My invention is capable of use in many new circuits. In Figure 2, I show one form where I have used a single tube to both transmit and receive radio signals. The basic principles are the same as shown in Figure 1. The input circuit includes the inductance **25**, which may be wound for the broadcast band, or for the shorter or ultra short frequencies, the microphone **35**, the cathode **2**, the outer grid **6**, and the grid condenser **8**, the inductance **25** being shunted with a variable condenser **4** to tune the input circuit to the desired frequency or wave length. The output circuit includes the inner grid electrode **7**, the primary winding of the radio-frequency transformer **18**, choke coil **19**, the B battery and the cathode **2**. The plate or anode circuit includes the plate electrode **3**, radio-frequency choke coil **19**, variable non-inductive resistance **12**, telephone receiver **17**, B battery and cathode **2** of said vacuum tube **1**. The secondary winding of the transformer **18** is shunted by a variable condenser **20** so as to tune the transmitting system to any preferable wave length. The aerial **22** is connected to either the transmitting circuit or to the receiving circuit by the selective switch **21**. In operation the switch **21** is moved to the right contact T to transmit and to the left contact R to receive, this being the only change necessary, unless resistance **12** needs adjusting. The drawing is largely self-explanatory. It is also to be understood that condenser **20**, and the secondary winding of transformer **18** may not be used to obtain a combined one tube transmitter and receiver. In this instance, when switch is moved to the left contact R, the aerial is connected direct to one side of inductance **25**, the opposite side of said inductance being connected to ground. Also in this instance, the switch **21** is not necessary but the transmission is not near so efficient, as it is when the transformer **18** is used in the output.

The operation of Figure 2 to receive signals or as a radio receiving system is the same as Figure 1. The inductance **25** when connected as shown, together with the proper voltage relations previously and herein described, causes the system to be a super-regenerative receiving set. Preferred modifications of this system as a radio frequency amplifier, or as a detector of radio frequency modulated signals or voice, are adjusting by proper positive voltage relation of the grids and anode so that normally the system is in oscillation, and when the input circuit is tuned to the desired signal or frequency then said local oscillator is modulated by the modulated radio frequency signal which greatly amplifies the signal either radio or audio frequency. I have also found static is materially reduced also by this system. In some modifications, a telephone receiver connected serially in the inner grid circuit in lieu of the choke coil **19**, is preferable. The signals are much stronger in the inner grid circuit than in the plate circuit. To receive and transmit with Figure 1, the aerial and ground are

connected on opposite ends of inductance **25**, and the microphone serially with inductance **25** as shown in Figure 2. While to receive only with the super-regeneration or amplifier shown in Figure 1, the aerial and ground are connected to each end of inductance **25**, as in Figure 2.

In certain modifications, when said tube is oscillating, the anode or inner grid current is increased, while in other modifications the inner grid or anode current is decreased; said difference is caused by whether a positive or negative bias is used on control grid, and whether a positive or negative direction of current is mainly fed to said control grid.

In using a variable positive potential on the grid **6**, and a variable positive potential on the anode **3**, and a variable positive potential on grid **7**, it is preferable that the grid **6** or the anode **3** have the highest positive potential impressed thereon in said high electron emitting tube, and that the grid **7** be adjusted to a positive potential less than the maximum potential of said grid **6** or anode **3**. As many tubes of the same type differ in operating characteristics, and different type tubes have different general operating characteristics no set positive voltage can be specified for the grid **7**, grid **6** and the anode **5**. This can only be found by adjusting the independent voltages impressed on grid **7**, grid **6** and the anode **5**, where satisfactory or maximum operation as a generator of radio oscillation for the type of tube used. The amount of electron emission from the cathode, the size of the cathode, the distance between the tube elements, the size of the grids and anode, whether or not the grids have primary electron emission of their own, and whether the anode has primary electron emission of its own, the resistance in the grid circuits, the resistance or impedance in the anode circuit, and many other factors, affect directly what individual positive voltage that will need to be impressed upon the grid **7**, the grid **6** and the anode **5** for operation as a generator of radio oscillations.

The degree of the intensity of the pulsations or oscillations generated is controlled by the voltage relation of the tube elements, the rheostats **10**, or the resistance **12**.

The choke coils **19** are connected serially in the inner grid circuit and in the plate circuits. This is to allow radio pulsations to go freely through, but tending to stop any oscillations, and causing said oscillations generated by reason of the ohmic resistance, inductance, or capacity of the coils **25**, to virtually all go through the tube from the cathode **2** to the electrode **6**, or vice versa. This feature is more efficient when a cold electron emitting grid or electrode **6** is used.

In my many modifications, I have used many different voltage relations, some of them are 135 volts on both the inner grid and plate electrodes. Also 45, 90 and 180 volts negative on the outer grid electrode. I have also used 180 volts positive on the inner grid electrode, and 90 volts on the plate electrode. In three electrode embodiments, I have used 400 volts positive on inner grid and 200 volts negative on electrode **6**; also 200 volts positive on grid **7** electrode and 45 volts negative on the grid **6** electrode, and in many other voltage relations. Also in some instances I have used the outer grid at the same potential as a single terminal cathode.

It is understood that I am not limited to the forms of my inventions as herein disclosed.

Some of my inventions herein comprise resonant circuits, which uses no coil or coils, and applies mainly to ultra short waves and fractional meter waves. Said circuits being disposed parallel and close together and one or all of said circuits adjustable as to length.

Another of my inventions uses cold flat like plate electrodes for cathode and/or anode, coated with cesium oxide, which makes an efficient relative cold electron tube, as electrons of substances such as, calcium, strontium, barium, and cesium oxide, can only be charged negatively, in a vacuum tube, this is better described in my prior filed applications; one example, being Serial No. 685,033, filed August 10, 1933.

My invention may be used as oscillators, amplifiers, public address systems, for the movies, detectors of radio oscillations, regenerative receiving and transmitting systems, super-regenerative circuits, hearing apparatus for the deaf, and for similar analogous purposes.

Having described my invention what I claim as new and desire to secure by Letters Patent of the United States of America is:

A regenerative receiving system and an oscillating transmitting system comprising an electron tube having a cathode, an anode, an inner grid, and an outer grid; a radio-frequency transformer having primary and secondary windings; aerial and ground wires; an anode circuit having said cathode, said anode, a telephone receiver and a source of electrical energy connected serially therein; an outer grid circuit having said cathode, a condenser, a radio-frequency inductance, a microphone, and a source of electrical energy connected serially therein, said condenser shunted by a non-inductive resistance element, and said radio-frequency inductance shunted by a tuning condenser which primarily determines the frequency of the radio-oscillations generated or received; an inner grid circuit having said cathode, said inner grid, the primary winding of said radio-frequency transformer, and a source of electrical energy connected serially therein, said secondary winding of said radio-frequency transformer tunable in resonance with said radio-frequency inductance of said outer grid circuit; and a two way switch means to selectively connect said aerial to the secondary winding of said radio-frequency transformer for radio transmission and to the said radio-frequency inductance for the regenerative reception of radio signals.

FRANK E. SUMMERS.