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TUNED ULTRA HIGH FREQUENCY AMPLIFIER

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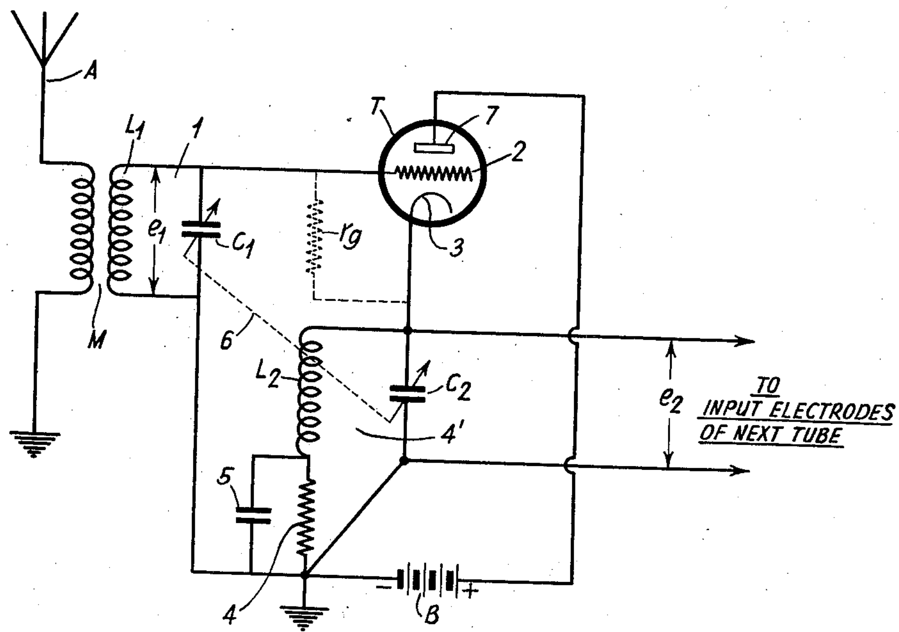

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TUNED ULTRA HIGH FREQUENCY AMPLIFIER

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5 Claims. (Cl. 179—171)

My present invention relates to tuned ultra high frequency amplifiers, and more particularly to circuits tuned to ultra high frequencies and coupled in cascade by electron discharge tube amplifiers.

In cascading parallel resonant circuits, which are tuned to radio frequencies of the order of 50 megacycles, by amplifier tubes serious loss of selectivity is encountered. Electron discharge tube amplifiers have a control grid-cathode resistance, the input resistance of the amplifier tube, which decreases rapidly as the operating frequency increases. For example, an electron discharge tube which exhibits an input resistance of several megohms in the standard broadcast range of 500 to 1500 kc., may have its input resistance magnitude reduced to just a few hundred ohms at very high frequencies. When an electron discharge tube is used to amplify the alternating current voltage developed across a parallel resonant circuit, the input resistance of the tube is shunted across the resonant circuit. Since the equivalent series resistance of the resonant circuit is inversely related to the shunt resistance provided by the aforesaid input resistance, it will be appreciated that at ultra high frequencies the damping effect of the extremely low tube input resistance on the resonant circuit is enormous. The circuit Q, or selectivity factor, may even be reduced as much as ten times.

Now I have discovered a method of, and devised means for, substantially minimizing the shunt action of the amplifier tube input resistance on a preceding resonant input circuit and thereby improving to a substantial extent the selectivity of the resonant input circuit; the method employed generally involving increasing the amplifier input resistance at resonance by an impedance disposed in series relation with the input resistance, and the series impedance exhibiting very high impedance value at resonance. Furthermore, this increase in selectivity is secured without appreciable circuit changes, nor with any interference with the normal operation of cascaded tuned radio frequency amplifier circuits.

Accordingly, it may be stated that it is one of the main objects of my present invention to provide a pair of resonant circuits which are both tuned to a common operating ultra high frequency, and which circuits are cascaded by an electron discharge tube; the control grid and cathode of the tube being connected across the preceding resonant circuit, and the following resonant circuit being disposed in the cathode circuit of the tube whereby at resonance it has a substantially infinite impedance arranged in series with the control grid to cathode resistance of the tube, the tube input resistance being relatively high at resonance and having little damping effect on the preceding resonant input circuit.

Still other objects of the invention are generally to improve the efficiency of operation of tuned ultra high frequency amplifier circuits, and more especially to provide such a circuit with maximum selectivity and with the utilization of minimum additional circuit elements.

The novel features which I believe to be characteristic of my invention are set forth in particularity in the appended claims; the invention itself, however, as to both its organization and method of operation will best be understood by reference to the following description taken in connection with the drawing in which I have indicated diagrammatically a circuit organization whereby my invention may be carried into effect.

Referring now to the accompanying drawing, there is shown an ultra high frequency amplifier circuit which includes at least two resonant circuits coupled in cascade by an electron discharge tube T. The source of signal energy A may be of any well known type. For example it may be a grounded antenna circuit, a loop antenna; an ultra high radio frequency distribution line; or an antenna of the dipole type. Regardless of the construction of the signal collector A, it is coupled, as at M, to the coil L_1 of the resonant input circuit 1 of the amplifier tube T. In shunt with the coil L_1 there is connected a condenser C_1, and it is denoted as variable so that the circuit 1 may be adjusted in tuning over a relatively wide frequency range if such adjustment is desired. The frequency range may be, for example, such as to include the ultra high radio frequencies of the order of 50 megacycles. It is to be clearly understood that this frequency value is merely given for illustrative purposes; stated in terms of meters, the signal wave range may be such as to receive waves as short as 0.1 meter. Generally speaking the signal wave range is that in which the control grid to cathode resistance of tube T has an appreciable damping effect on the input circuit 1.

As shown in the drawing the control grid 2 of tube T is connected to the high alternating potential side of circuit 1. The cathode 3 is connected to a point of relatively fixed radio frequency potential, as ground, through a path which includes coil L_2 and condenser **5**. The latter has a low impedance to the ultra high frequencies to be amplified; it is in shunt with resistor **4** functioning as the grid bias resistor. The resistor **4** may have a magnitude of 1000 ohms, and is in series between the low potential side of coil L_2 and the low potential side of input circuit **1**. The variable condenser C_2 is in shunt with coil L_2 to provide the second tuned circuit **4'**; the rotor of condenser **4'** is connected to ground so that the rotors of condenser C_1 and C_2 may be operated by a common grounded shaft, designated by the dotted line **6**. The signal voltage e_2 developed across circuit **4'** is impressed between the input electrodes of a following tube. The latter may be another amplifier. or a detector tube.

The plate, or anode, **7** of tube T is connected to a positive point on voltage source B; the negative terminal of the latter being connected to the grounded side of self-bias resistor **4**. The circuits **1** and **4'** are shown arranged for tuning to a common operating carrier frequency. The circuits **1** and **4'** may be fixedly tuned to a desired frequency. The signal voltage e_1 developed across circuit **1** is amplified by tube T; the amplified voltage e_2 is utilized in any desired manner. The selectivity of circuit **1** is greatly improved over what it would have been with circuit **4'** disposed in the anode circuit in the conventional manner.

With such conventional arrangement the input resistance r_g (shown in dotted line in the figure) would exert a very high damping effect on circuit **1**, and thus greatly reduce its selectivity. This follows from the fact that at the operating ultra high frequencies, the resistance r_g has a small value. Since this resistance would be in shunt across circuit **1**, the equivalent series resistance in the circuit **1** is high; an inverse relation existing between the shunt resistance and its equivalent series value.

By inserting the circuit **4'** in the cathode circuit of tube T, there is produced the voltage e_2 opposite in sign to e_1, thus making the voltage impressed across grid to cathode of tube T very small. The effect of r_g as a dissipator of power is small, and the equivalent shunting resistance, R_d, of r_g and circuit **4'** in series is made large. The magnitude of R_d may be derived as follows:

$$R_d=\frac{r_g}{1-\frac{\mu Z}{r_p+Z(\mu+1)}}$$

where, $Z=2\pi f_0 L_2 Q_2$

r_p = plate resistance of tube T

Q_2 = Inductive reactance of circuit **4'** divided by its resistance.

It will be understood that the selectivity of circuit **4'** can be maintained high by coupling to a following tuned circuit in the manner already described. The resistance R_d is always higher than r_g, and in actual practice may be made much higher. To review the functioning of this network disclosed herein, at resonance the impedance of circuit **4'** is high, and the voltage e_2 is developed across it by virtue of the plate current flow through **4'**. This voltage opposes the voltage developed across condenser C_1, and thus the voltage between grid and cathode of tube T is small. With a small grid voltage the loss of power in resistor r_g is small, and therefore, the effective shunt resistance R_d which produces a power loss across tuned circuit **1** is large.

While I have indicated and described a system for carrying my invention into effect, it will be apparent to one skilled in the art that my invention is by no means limited to the particular organization shown and described, but that many modifications may be made without departing from the scope of my invention, as set forth in the appended claims.

What I claim is:

1. In an amplifier of the type including a tube provided with at least a cathode, control grid and anode, a resonant circuit connected between the grid and a point of relatively fixed potential, said circuit being tuned to a carrier frequency at which the grid to cathode resistance of the tube substantially damps the resonant circuit, a direct current source connected between the anode and said point, a second resonant circuit, tuned to said carrier frequency, connected between the cathode and said point thereby substantially minimizing said damping effect, and means for impressing carrier voltage developed across the second circuit upon an output circuit.

2. In an amplifier of the type including a tube provided with at least a cathode, control grid and anode, a resonant circuit connected between the grid and a point of relatively fixed potential. said circuit being tuned to a carrier frequency at which the grid to cathode resistance of the tube substantially damps the resonant circuit, a direct current source connected between the anode and said point, a second resonant circuit, tuned to said carrier frequency, connected between the cathode and said point thereby substantially minimizing said damping effect, and means for impressing carrier voltage developed across the second circuit upon an output circuit, said second resonant circuit including a coil in series with a resistor between the cathode and said point, and means for bypassing current of carrier frequency around said resistor, said resistor establishing the grid at a desired negative bias.

3. In an amplifier of the type including a tube provided with at least a cathode, control grid and anode, a resonant circuit connected between the grid and a point of relatively fixed potential, said circuit being tuned to a carrier frequency at which the grid to cathode resistance of the tube substantially damps the resonant circuit, a direct current source connected between the anode and said point, a second resonant circuit, tuned to said carrier frequency, connected between the cathode and said point thereby substantially minimizing said damping effect, means for impressing carrier voltage developed across the second circuit upon an output circuit, each of said resonant circuits being parallel resonant, and means for tuning said resonant circuits over a range of ultra high frequencies.

4. In an amplifier of the type including a tube and a parallel resonant circuit connected between the control grid and cathode of the tube, said circuit being tuned to a frequency lying in the ultra high frequency range, the control grid to cathode resistance of the tube being sufficiently small at said frequency to greatly damp said circuit, and a second parallel resonant circuit, tuned to said frequency, arranged in the space current path of said tube and connected between said control grid and cathode in series with said first resonant circuit thereby substantially to minimize said damping effect of said resistance and maintain high selectivity of said amplifier.

5. In an amplifier of the type including a tube and a parallel resonant circuit connected between the control grid and cathode of the tube, said

circuit being tuned to a frequency lying in the ultra high frequency range, the control grid to cathode resistance of the tube being sufficiently small at said frequency to greatly damp said circuit, and a second parallel resonant circuit, tuned to said frequency, arranged in the space current path of said tube and connected between said control grid and cathode in series with said first resonant circuit thereby substantially to minimize said damping effect of said resistance and maintain high selectivity of said amplifier, and means for impressing high frequency voltage developed across the second resonant circuit upon a utilization network.

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