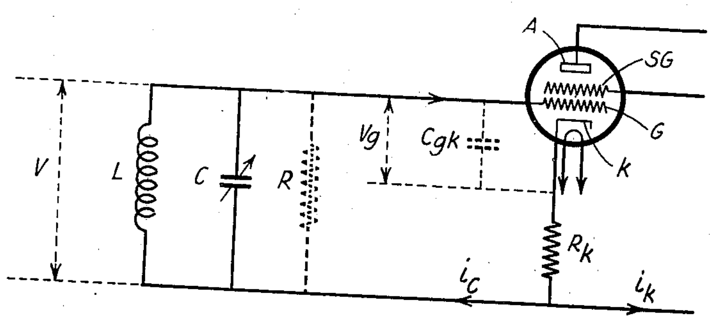
Aug. 27, 1940. A. VAN DER ZIEL 2,212,851

SYSTEM FOR AMPLIFYING ELECTRICAL OSCILLATIONS

Filed Sept. 26, 1936



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Patented Aug. 27, 1940 2,212,851

UNITED STATES PATENT OFFICE

2,212,851

SYSTEM FOR AMPLIFYING ELECTRICAL OSCILLATIONS

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Application September 26, 1936, Serial No. 102,727
In Germany October 18, 1935

7 Claims. (Cl. 179—171)

The invention relates to amplifying systems for very high frequencies wherein the control grid and the cathode of one or more amplifying tubes are connected to a tuned oscillatory circuit.

When voltages of very high frequency are applied to the electrodes of a thermionic tube, damping occurs, as is well-known, between the control grid and the cathode of the tube due to the fact that the transit time of the electrons is not negligibly small with respect to the period of the voltages applied. This damping, which is hereinafter referred to as "transit time damping," has been calculated by C. J. Bakker and G. de Vries in an article: "On vacuum tube electronics" published in Physica 2, pages 683–697, July, 1935. According to said article the transit time damping is equal to

$$\frac{1}{R}=\frac{1}{20}S\omega^2t^2$$

where S is the steepness of the characteristic curve which indicates the relation between the total current flowing through the control grid and the control grid voltage while ω represents the angular frequency of the high-frequency voltages applied and t the transit time of the electrons between the cathode and the control grid.

If, as is customary, the amplification of the system is regulated by causing the bias voltage of the control grids of the amplifying tubes to vary, the slope and therefore also the transit time damping have different values for every value of the amplification. If an oscillatory circuit is connected between the control grid and the cathode of one or more of the amplifying tubes, the damping of this circuit and therefore the selectivity of the system will be different for every value of the amplification.

A damping effect which depends on the steepness of an amplifying tube may be obtained, as is well-known, by connecting a resistance into the cathode lead of the tube.

In a system for amplifying electrical oscillations of very high frequency wherein the control grid and the cathode of one or more amplifying tubes are connected to an oscillatory circuit tuned to the frequency of the oscillations to be amplified, a selectivity which is independent of the amplification is obtained, according to the invention, by including in the cathode lead of the tube or tubes a resistance of such value that the variation of transit time damping with amplification is compensated for.

The invention will be explained more fully with reference to the accompanying drawing.

The drawing represents a screen grid tube wherein the control grid G and the cathode K are connected to a tuned oscillatory circuit consisting of an inductance L and a variable capacity C. The damping of the oscillatory circuit is represented by the parallel resistance R (shown dotted). The cathode lead of the tube includes a resistance R_k while the capacity between the control grid and the cathode is represented by C_{gk}.

The voltage across the oscillatory circuit is V and the voltage between the control grid and the cathode is V_g. Furthermore, the current flowing through the capacity C_{gk} is denoted by i_c and the current taken up by the anode A and the screen grid SG by i_k.

If now the reaction of the anode and of the screen grid is negligible, then:

$$i_k=SV_g$$

Furthermore: $i_c=j\omega C_{gk}V_g$

Consequently $V=V_g+(i_k+i_c)R_k=V_g[1+R_k(S+j\omega C_{gk})]$

In parallel with the oscillatory circuit is consequently located an impedance:

$$Z_g=\frac{V}{i_c}=\frac{1+R_k(S+j\omega C_{gk})}{j\omega C_{gk}}$$

It results therefrom that:

$$\frac{1}{Z_g}=\frac{j\omega C_{gk}}{1+SR_k+J\omega C_{gk}R_k}=\frac{j\omega C_{gk}(1+SR_k)+\omega^2C_{gk}{}^2R_k}{(1+SR_k)^2+(\omega C_{gk}R_k)^2}$$

The damping produced by the resistance R_k consequently amounts to

$$\frac{\omega^2C_{gk}{}^2R_k}{(1+SR_k)^2+(\omega C_{gk}R_k)^2}$$

With wave-lengths of about 6 to 12 meters

$$\omega C_{gk}R_k<<1 \qquad (a)$$

For the damping caused by the resistance R_k one consequently finds approximately:

$$\frac{\omega^2C_{gk}{}^2R_k}{(1+SR_k)^2}\cong\omega^2C_{gk}{}^2R_k(1-2SR_k) \text{ if } SR_k<<1 \qquad (b)$$

This damping has a positive term: $\omega^2C_{gk}{}^2R_k$ which is not dependent on the steepness, and a negative and consequently relatively undamping term $-2\omega^2C_{gk}{}^2R_k{}^2S$, which is proportional to the steepness. Now the value of the resistance R_k is so chosen that

$$\frac{S\omega^2t^2}{20}=2(\omega C_{gk}R_k)^2S$$

or

$$R_k=\frac{t}{2C_{gk}\sqrt{10}}$$

If this condition is satisfied and the value of R_k does not turn out so great as to contradict assumptions (a) and (b) above, the total damping of the oscillatory circuit is:

$$\omega^2C_{gk}{}^2R_k$$

This damping is consequently independent of the steepness of the amplifying tube, i. e. the selectivity of the system is independent of the bias voltages of the control grids of the amplifying tubes.

What I claim is:

1. System for amplifying electrical oscillations of very high frequency, wherein the control grid and the cathode of an amplifying tube are connected to an oscillatory circuit tuned to the frequency of the oscillations to be amplified, the cathode lead of said amplifying tube comprising a resistance of such value that the transit time damping is compensated for.

2. An amplifying system as defined in the preceding claim wherein the resistance is equal to

$$\frac{t}{2C_{gk}\sqrt{10}}$$

t representing the transit time of the electrons between the cathode and the control grid, and C_{gk}, the interelectrode capacity between the control grid and the cathode.

3. A system for the amplification of high frequency oscillations comprising a vacuum tube amplifier having grid and cathode electrodes, a tunable circuit connected to said grid and cathode, and a bias resistance connected to the cathode, said bias resistance being so proportioned to the damping between said grid and cathode due to the transit time of the electrodes that the selectivity of the system is independent of amplification.

4. In combination, a vacuum tube amplifying circuit operating in a range of high frequencies at which the transit time of the electrons in the tube causes damping of the tube input circuit, said transit time damping varying with changes in the bias voltage applied to the control grid of the tube, and a resistance connected to the cathode of said tube and being of such value that the transit time damping is substantially independent of changes in the control grid biasing voltage.

5. In combination, a vacuum tube amplifying circuit operating in a range of high frequencies at which the transit time of the electrons in the tube causes damping of the tube input circuit, said transit time damping varying with changes in the biasing voltage applied to the control grid of the tube, a tuned circuit connected to the tube input, the transit time damping variations causing the selectivity of the tuned circuit to vary, and a resistance connected to the cathode of said tube and being of such value that the selectivity of the tuned circuit is made substantially independent of changes in control grid biasing voltage.

6. A system for the amplification of high frequencies comprising a vacuum tube amplifier provided with a plurality of electrodes including a control grid and a cathode, an input circuit connected between said control grid and cathode, said system operating at frequencies so high that the transit time of the electrons in the tube causes variations in the damping of tube input circuit with changes in the biasing voltage applied to the control grid, and means comprising a resistance connected to the cathode whereby the damping due to the electron transit time is substantially compensated for.

7. A system for the amplification of high frequency oscillations comprising a vacuum tube amplifier provided with a plurality of electrodes including an input control grid and a cathode, said system operating at frequencies so high that the transit time of the electrons in the tube causes appreciable conductance between said grid and cathode, said input conductance varying with changes in applied control grid bias voltage, a tunable circuit connected between said control grid and cathode and being affected by the variations in said input conductance to vary its selectivity, and means comprising a resistance connected to the cathode whereby said variation in input conductance is substantially compensated for, to provide a system in which the selectivity is independent of the changes in the bias voltage.

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