Oct. 26, 1943. W. KLEEN 2,332,919

AMPLIFIER CIRCUIT FOR ULTRA-SHORT WAVES

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Fig. 1

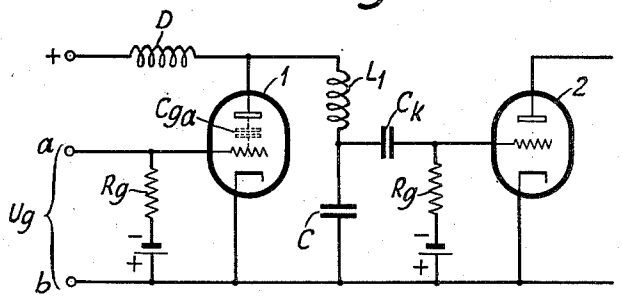


Fig. 2

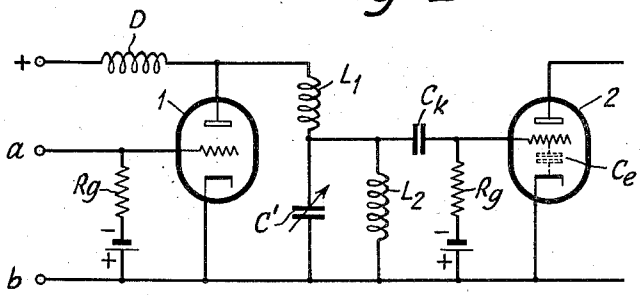
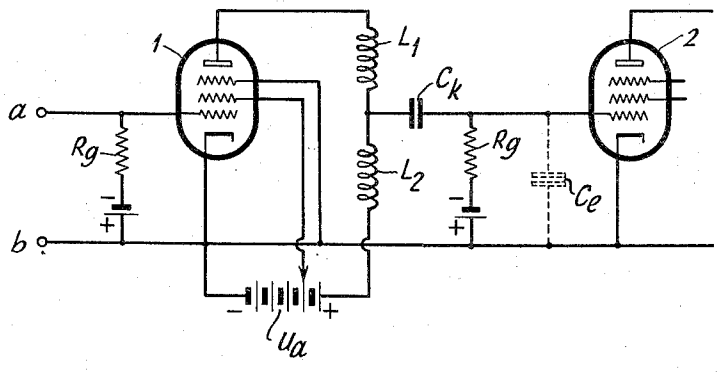


Fig. 3



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AMPLIFIER CIRCUIT FOR ULTRA SHORT WAVES

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2 Claims. (Cl. 179—171)

In all amplifier circuits the reaction by the plate alternating potential by virtue of the grid-plate capacitance upon the control grid is extremely annoying, for it means that the input and the output circuits are no longer independent of each other; indeed, they are coupled by an impedance the size of which is determined by the grid-plate capacitance. The plate reaction is particularly strong in the case of ultra-short waves, that is, waves of a length less than 5 meters, for the reason that in this wave band the alternating-current resistance of the grid-plate capacitance is extremely low and thus the coupling between input and output circuits very strong. Now, the invention hereinafter to be described is suited to completely eliminate the plate reaction.

The plate reaction must be obviated entirely if the occurrence of an alternating potential at the plate is wholly avoided, and this is feasible if the plate circuit is designed in the form of a series resonant circuit tuned to the operating frequency and which consists of an inductance and a capacity. The amplified potential may be derived from across one of the two elements of the series resonant circuit and fed to the input circuit of the next stage. Preferably the series resonant circuit is associated with the tube in such a way that the inductance is united with the plate and the capacity with the cathode, the amplified potential being derived from across the capacity. This arrangement is expedient for the reason that the input capacitance of the following tube is connected in parallel to the capacity of the series-resonant circuit or may act as such.

The invention will now be described in connection with the accompanying drawing in which Figs. 1, 2 and 3 disclose circuits embodying various modifications according to the invention.

Referring to Fig. 1, there is shown the tube 1 upon the control grid of which, that is, across the terminals *a* and *b*, there is impressed the alternating potential U_g to be amplified, while by way of a high resistance grid leak R_g a grid biasing voltage is impressed. Between plate and cathode is the series resonant circuit comprising the inductance L_1 and the capacity C and tuned to the input alternating potential U_g. The D. C. plate voltage is supplied through a choke coil D. Inasmuch as the series resonant circuit constitutes a short-circuit for the operating frequency, no alternating potential at all will arise at the plate of tube 1, and this means that reaction by the plate alternating voltage through the grid-plate capacitance C_{ga} upon the control grid is entirely precluded. The amplified alternating potential is taken off at the capacity C and then through a coupling condenser C_k which represents a negligibly low resistance for the operating frequency, is impressed upon the control grid of the following tube 2. Also the control grid of the latter tube, through a high-ohm leak resistance R_g is impressed with a negative biasing voltage for the purpose of fixing the operating point.

In the amplification of ultra-short waves, that is, wave-lengths less than 5 meters, the foregoing circuit organization fails to furnish sufficient amplification, as can be demonstrated by the following considerations: Capacitor C is connected in parallel relation to the input capacity of tube 2. The capacity acting in the series resonant circuit is at least equal to the input capacity of tube 2, and this capacity as a general rule can not be made less than 3 mmf. It is known in the art that the alternating-current resistance Z of a capacity, for a wave-length λ, is calculable by this formula:

$$Z=\frac{530.\lambda}{C}$$

where λ is in terms of meters, and C in mmf. while Z is in ohm values. For $\lambda=1$ meter and C=3 mmf. there follows that Z=180 ohms. For the alternating potential U_c which arises at the capacity C there holds good the relation $U_c=S_m.\,Z.\,U_g$. Inasmuch as the slope S_m (mutual conductance), in the conventional kind of short-wave tube, may be taken to be around 2 mA/V, there results for the case cited $U_c=.36U_g$. In other words, tube 1 fails to give gain; in fact, the input alternating potential U_g is reduced. However, this drawback may be obviated by the step as hereinafter outlined.

In an amplifier circuit organization for ultra-short waves in which the output circuit is a series resonant circuit and in which the output potential for the following stage is taken from across the capacity of the series resonant circuit, the capacitive element or component of the series resonant circuit according to the invention, consists of the input capacity of the next tube and a capacity optionally connected in parallel relation thereto on the one hand, and an inductance connected in parallel relation thereto on the other hand, the inductance being chosen of such dimension that together with the capacity in parallel thereto it represents a capacitive impedance (reactance) which is essentially smaller than the input capacity. This shall now be ex-

plained by reference to the circuit shown in Fig. 2. The arrangement comprises the same elements as shown in the circuit of Fig. 1, but in addition an inductance L_2 which is arranged in parallel relation to the capacity of the series resonant circuit. The fly-wheel circuit consisting of the inductance L_2, the input capacity C_e and optionally an additional capacity C' is so detuned in reference to the frequency to be amplified, in other words, is tuned to a so much lower frequency, that the fly-wheel circuit, for the operating frequency, acts like a capacity which is far lower than the input capacity C_e. Proper tuning may be effected, for instance, by variation of the capacity C', unless it is preferred to dispense with the capacity C' and to use for the capacitive component of the series resonant circuit only the input capacity C_e. In this latter instance, the tuning of the fly-wheel circuit C_eL_2 is brought about either by suitable choice of the inductance L_2 or else by variation of the input capacity C_e. The latter scheme is feasible for the reason that the input capacity is a function of the discharge density between the cathode and the control grid so that it is open to action in a circuitous way through the discharge current of tube 2. Hence, if the fly-wheel circuit operative between the control grid and the cathode of tube 2 is tuned in such a way that it represents for the operating frequency a capacity of, say, 0.3 mmf., in the light of the data and relations before-mentioned, for a wave-length of 1 meter, this corresponds to an impedance of 1800 ohms. Assuming a slope of 2 mA/V, an input potential results at the grid of tube 2 which is 3.6 times higher than the alternating potential U_g fed to the grid of tube 1; in other words, the voltage gain is 3.6.

Fig. 3 shows another embodiment of the circuit organization of this invention in which the input capacity C_e serves as the capacity of the series resonant circuit, of which by means of the inductance L_2 part is "tuned away." In the form of construction here shown the blocking condenser C_k is inserted in the lead brought to the control grid of the tube 2 in such a way that the additional inductance L_2 is included in the D. C. plate circuit of tube 1. However, the blocking condenser could also be connected between L_1 and L_2 so that the additional inductance L_2, in respect to D. C. pertains to the grid circuit of tube 2.

In designing the circuit organization of the invention it is recommendable to use tubes fitted with a screen grid between control grid and plate, or, optionally, fitted with an additional suppressor grid between the screen grid and the plate. If the series resonance circuit hereinbefore described which is used to act as an external resistance had no damping, no alternating potential would arise between plate and cathode of the tube; hence, no reaction would arise regardless of what the value of the grid-plate capacitance might be. However, inasmuch as damping in the series resonant circuit is inevitable, especially where short waves are dealt with, a small alternating potential will always be present. For this reason it will be expendient, in order to minimize the reaction by way of C_{ga}, to employ a pentode instead of a triode, for in this case the value of C_{ga} would be several orders of magnitude lower than for a triode.

What I claim is:

1. Amplifier circuit for ultra-short waves, in which the output circuit of the first stage is in the form of a series resonant circuit tuned to the operating frequency, and in which the input potential for the following stage is derived from across the capacity of the series resonant circuit, with the characteristic feature that the capacitive component of the series resonant circuit is formed by the input capacity of the following tube and a capacitance connected in parallel relationship thereto, and further an inductance arranged in parallel to it, the inductance being proportioned in such a way that together with the capacity paralleled thereto it represents a capacitive impedance which is substantially lower than the input capacity of the following tube.

2. Amplifier circuit for ultra-short waves comprising first and second tubes, a series-resonant circuit consisting of inductance and capacity forming the output circuit of the first tube, the capacity of said series-resonant circuit being constituted by the grid to cathode capacity of the second tube, a second inductance connected in shunt to the capacity of the series-resonant circuit, and a coupling condenser connected from the common terminal of the resonant circuit elements to the grid of the second tube.

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