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PUSH-PULL AMPLIFYING SYSTEMS FOR
ULTRA-HIGH FREQUENCIES
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Fig. 1

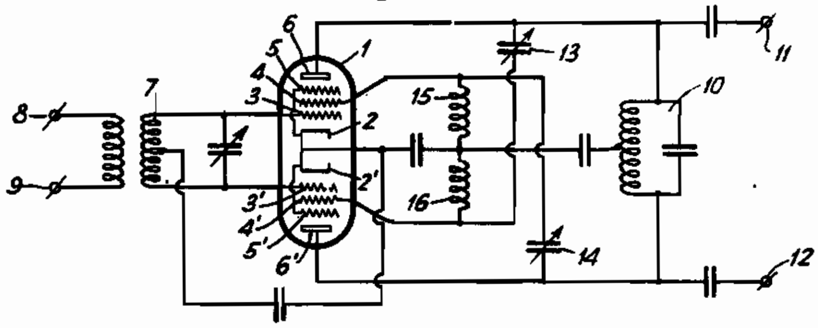


Fig. 2

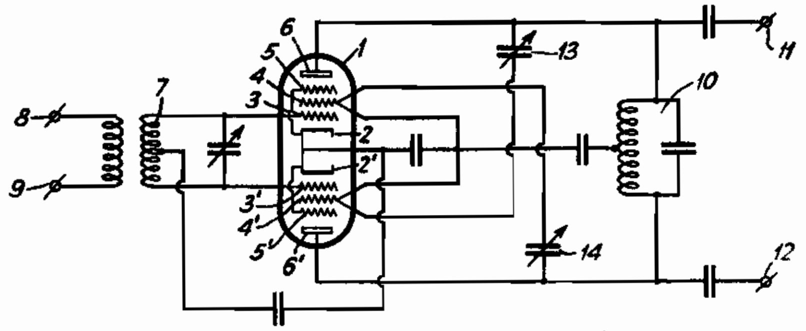
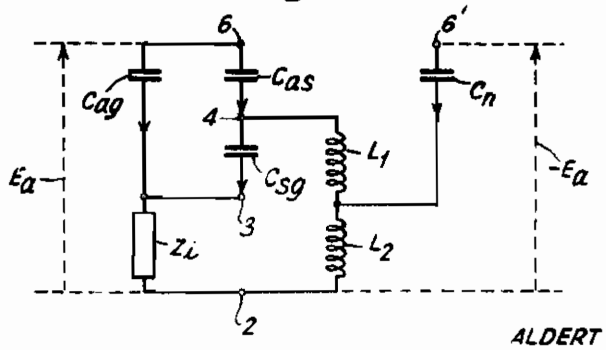


Fig. 3



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ALIEN PROPERTY CUSTODIAN

PUSH-PULL AMPLIFYING SYSTEMS FOR ULTRA-HIGH FREQUENCIES

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The invention relates to an amplifying system for ultra-high frequencies which comprises two amplifying systems in push-pull connection which are each constituted at least by a cathode, a control grid, a screen grid and an anode and it has for its purpose to provide means for neutralizing in such a system the retroaction of the anode voltage on the control-grid circuit.

With the usual broadcast frequencies this retroaction is almost exclusively caused by the anode-control grid capacity C_{ag}. With higher frequecies the self-inductions and the mutual inductions of the supply conductors leading to the tube electrode also play a part with the result that the phenomena become much more complicated. However, for these higher frequencies, the retroaction may still be imagined to be brought about by a capacity C_{ag}' which is operative between the anode and the control grid and for which we may write

$$C_{ag}'=C_{ag}-\omega^2 A$$

in which equation ω represents the angular frequency of the oscillations to be amplified and A is a constant determined by the construction of the tube.

It may be seen from the above equation that for every amplifying tube there exists a critical frequency for which $C_{ag}=\omega^2 A$ and there consequently occurs no retroaction at all. With the tube AF3 this critical frequency amounts, for example, to about 20 megacycles per second. For frequencies above the critical frequency there occurs between the anode and the control grid a negative capacity the value of which may be considerably larger than that of the static anode-control grid capacity C_{ag}.

With screen-grid tubes the static anode-control grid capacity is as a rule very slight (for example about 0.003 $\mu\mu$F) so that at frequencies below the critical frequency there is in general no need for neutralization of the retroaction. At frequencies exceeding the critical frequency, however, the retroaction may be very appreciable also with screen-grid tubes. Fundamentally it would in this case be possible to neutralize the retroaction by artificially increasing the anode-control grid capacity, that is to say by arranging a regulable condenser between the anode and the control grid and by adjusting this condenser in such manner that the resulting capacity between the anode and the control grid is equal to ω^2A. In practice, however, this method cannot be carried into effect since an adjustable condenser of the very low capacity required therefor is impracticable.

It is known to neutralize the retroaction with a push-pull amplifying system by connecting the anode of each of the amplifying tubes via an adjustable condenser to the control grid of the other tube. This known method only permits, however, to neutralize a positive anode-control grid capacity so that with frequencies exceeding the critical frequency it is impracticable.

The invention has for its object to provide means for neutralizing the retroaction in a push-pull amplifying system, with which the frequency of the oscillations to be amplified exceeds the critical frequency.

According to the invention, the retroaction exerted by the anode voltage on the control-grid circuit is neutralized in each of the amplifying systems by connecting a point of the circuit of one of the other electrodes of the amplifying system in question through an adjustable condenser to the anode of the other amplifying system, a self-induction being present in the high-frequency connection between the said point and the mid-point of the input circuit.

Preferably, a point of the screen-grid circuit of each of the amplifying systems is connected through an adjustable condenser to the anode of the other amplifying system.

The invention will be explained more fully with reference to the accompanying drawing which represents, by way of example, two embodiments thereof.

Fig. 1 represents a push-pull amplifying tube 1 comprising two amplifying systems the upper one of which consists of a cathode 2, a control grid 3, a screen grid 4, a suppressor grid 5 connected to the cathode and an anode 6 whilst the other amplifying system consists of similar electrodes denoted by primed reference numerals. In order to reduce to a minimum the self-induction of that part of the cathode lead which carries alternating current, which self-induction gives rise to damping of the input circuit, the two cathodes 2 and 2' are preferably formed as one unit or connected to one another by means of a conductor which is as short as possible.

An input oscillatory circuit 7 is connected in phsh-pull connection to the control grids 3 and 3'. The oscillations to be amplified are supplied to terminals 8 and 9 and inductively transmitted to the circuit 7. Between the anodes 6 and 6' is provided an output oscillatory circuit 10 the ends of which are connected, through the intermediary of separating condensers, to output terminals 11 and 12. The mid-point of the circuit 7 and the mid-point of the circuit 10 are connected to the cathodes 2 and 2′ through condensers which form a short-circuit for the frequency of the oscillations to be amplified.

The anode 6 of the upper amplifying system is connected through an adjustable neutralizing condenser 13 to the screen grid 4′ of the lower amplifying system whilst the anode 6′ of the lower amplifying system is connected through a similar condenser 14 to the screen grid 4 of the upper amplifying system. Between the screen grids 4 and 4′ and the cathode are provided self-inductances 15 and 16.

If the frequency of the oscillations to be amplified exceeds the critical frequency of the amplifying systems the exact adjustment of the condensers 13 and 14 permits to neutralize the retroaction completely.

The function of the inductances 15 and 16 may also be performed by the natural self-inductions of the supply conductors of the screen grids 4 and 4′ as is shown in Fig. 2. To that end the two screen grids must each be provided with two separated supply conductors, each screen grid being connected through one of these supply conductors to the cathode of the amplifying system in question and through the other supply conductor via a neutralizing condenser to the anode of the other amplifying system.

The operation of the systems according to Figs. 1 and 2 will be explained more fully with reference to Fig. 3 which represents a simplified substitution diagram which only exhibits the principal impedances which play a part in the production and in the neutralization of the retroaction. This substitution diagram applies to one of the amplifying systems; for the other amplifying system may naturally be plotted a similar substitution diagram.

In Fig. 3 the anode-control grid capacity is denoted by C_{ag}, the anode-screen grid capacity by C_{as} and the screen grid-control grid capacity by C_{sg}. That portion of the input impedance which is located between the control grid 3 and the cathode is denoted by Z_i whilst C_n denotes the capacity of the neutralizing condenser 14.

For the system according to Fig. 1, L_1 is the natural self-induction of the supply conductor of the screen grid 4 whilst L_2 denotes the self-induction of the coil 15. With the system according to Fig. 2, $L_1=0$ whilst L_2 represents the natural self-induction of the supply conductor of the screen grid 4, which conductor is connected to the cathode. The anode alternating voltage of the upper amplifying system is denoted by E_a, that of the lower amplifying system by $-E_a$. The arrows indicate the direction of the currents flowing in the various impedances.

The substitution diagram according to Fig. 3 is in so far incomplete that in practice also the self-inductions of the supply conductors leading to the suppressor grid and the cathode and the capacities of these electrodes with respect to the anode, the screen grid and the control grid as well as the mutual inductions of the supply conductors may play a part. These impedances, however, are in practice of less importance.

The impedances of the capacities C_{ag}, C_{as}, C_{sg} and C_n are in practice high with respect to Z_i and to the impedances of the self-inductances L_1 and L_2. With complete neutralization the voltages E_a and $-E_a$ cause no voltage on the control grid so that the control grid alternating voltage may be assumed to be equal to zero.

Roughly stated the following values of currents and voltages may be assumed.

A current $j\omega C_{ag}.E_a$ flows through the capacity C_{ag} to the control grid.

Through the capacity C_{as} flows to the screen grid a current $j\omega C_{as}.E_a$ which sets up across the self-inductances L_1 and L_2 a voltage

$$-\omega^2 C_{as}(L_1+L_2).E_a$$

This voltage furnishes a current flowing to the control grid through the capacity C_{sg}, which current is equal to $-j\omega^3 C_{as}C_{sg}(L_1+L_2).E_a$ and consequently in counterphase with the current flowing through the capacity C_{ag} to the control grid, but is larger than the last-mentioned current since the frequency of the oscillations to be amplified exceeds the critical frequency.

Through the capacity C_n flows a current $-j\omega C_n.E_a$ which sets up across the self-inductance L_2 a voltage $\omega^2 C_n L_2.E_a$. This voltage furnishes a current to the control grid through the capacity C_{sg}, which current is equal to $j\omega^3 C_n C_{sg} L_2 E_a$ and is consequently in phase with the current flowing through the capacity C_{ag} to the control grid.

If $C_n L_2$ is made equal to $C_{as}(L_1+L_2)$ the retroaction exerted through the screen grid is completely suppressed so that there only remains the retroaction exerted via the small capacity C_{ag}. If it is desired to neutralize also the latter retroaction, C_n has to be taken slightly smaller. For the case of Fig. 2 it is consequently necessary to take for neutralization C_n equal to or slightly smaller than C_{as}.

In the circuit arrangements according to Figs. 1 and 2 a point of the screen-grid circuit of each of the amplifying systems is connected through a neutralizing condenser to the anode. Fundamentally it is also possible to choose therefor a point of the circuit of another electrode, for example of the cathode. In practice, however, the latter method is not recommended since in connection with the input damping brought about by the self-induction of the cathode lead this self-induction is preferably kept as small as possible.

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