Fig. 1

Fig. 2

Fig. 3
This invention relates to high-frequency amplifying circuit arrangements including two push-pull connected amplifying systems each comprising at least a cathode, a control-grid, and an anode and, if desired, one or more screen-grids located between the said control-grid and the anode, the cathodes of the two amplifying systems either constituting an assembly or being interconnected through as short a lead as possible, and the amplification being controlled by hand or automatically by simultaneous variation of the control-grid bias of the two amplifying systems.

High-frequency amplifiers, whose amplification is controlled by varying the control-grid bias, exhibit the drawback that the input capacity occurring between the control-grid and the cathode depends on the control-grid bias so that the tuning of the input-circuit is liable to variations during control. This drawback is particularly prevalent when amplifying short and ultra-short waves. It is known to make up for this undesirable variation of the input-capacity by inserting an ohmic resistance, which is not short-circuited for high frequencies, in that part of the cathode lead which is common to the anode-circuit and the control-grid circuit.

In amplifying ultra-short waves it is advantageous to make use of push-pull amplifying tubes comprising two amplifying systems either having a common cathode or two separated cathodes connected through as short a lead as possible, the input-impedance and the output-impedance being connected in push-pull arrangement to the control-grids and the anodes respectively of the two amplifying systems. The use of these push-pull amplifying tubes has the advantage that the self-inductance of the cathode lead part conveying alternating current is reduced to a minimum, as a result of which the input-damping caused by the said self-inductance is also a minimum.

When using such push-pull amplifying tubes it is not possible, however, to provide the cathode lead part conveying alternating current with an ohmic resistance making up for the variation of the input-capacity.

The present invention purports to compensate the variation of the input-capacity caused by amplification control in a circuit arrangement including a push-pull amplifying tube of the kind referred to above. According to the invention an ohmic resistance, which is not short-circuited for high frequencies, is for this purpose provided in each amplifying system in the alternating current conveying part of the anode-circuit and/or of the circuit of one or more of the said screen-grids, one end of the said resistance being connected for high frequencies to the cathode of the amplifying system in question, whereas the other end is connected through a capacity to the control-grid of the other amplifying system, the said ohmic resistances and capacities being so proportioned that the variation of the input-capacity of the circuit, which occurs during amplification control is entirely or substantially entirely made up for.

The invention will be more fully explained by reference to the drawings in which Figs. 1 to 6 represents, by way of example, several embodiments thereof. In the drawings, the direct-current connections have been omitted for the sake of simplicity.

Fig. 1 represents a push-pull amplifying tube comprising two pentode systems each consisting successively of a cathode, a control-grid, a screen-grid, a suppressor grid connected to the cathode and an anode. The cathodes of the two systems are interconnected through as short a lead as possible. An input-oscillatory circuit 2 is connected in push-pull arrangement to the control-grids of the two amplifying systems, and the center of this oscillatory circuit is connected to the common supply lead for the two cathodes through condensers 3 and 4 which constitute a short circuit for the frequency of the oscillations to be amplified. The oscillations to be amplified originating, for instance, from a dipole antenna are supplied to the terminals 5 and 6 and inductively transmitted to the oscillatory-circuit 2.

An output-oscillatory circuit 7 is connected in push-pull arrangement to the anodes of the two amplifying systems, the center of this oscillatory circuit being connected to the cathodes through a condenser 8 which constitutes a short-circuit for the frequency of the oscillations to be amplified. The ends of the oscillatory circuit 7 are connected through blocking condensers 9 and 10 to the terminals 11 and 12 from which the amplified oscillations are taken.

The amplification of the circuit is controlled by hand or automatically by supplying a variable bias C0 to the control-grids of the two amplifying systems. This bias may, for instance, be applied between the center of the oscillatory circuit 2 and the cathodes, as shown in each of the Figures 1 to 6.

According to the invention the screen-grid cir-
cuits of the two amplifying systems include ohmic resistances 13 and 14 of which the ends remote from the screen-grids are connected for high frequencies to the cathodes through the condenser 4. Furthermore the end of the resistance 13 facing the screen-grid of the upper amplifying system is connected through a condenser 15 to the control-grid of the bottom amplifying system, whereas the end of the resistance 14 facing the screen-grid of the bottom amplifying system is connected through a condenser 16 to the control-grid of the upper amplifying system. The resistances 13 and 14 and the condensers 15 and 16 are so proportioned that on the occurrence of a variation of the control-grid bias of the two amplifying systems the input-capacity set up between the control-grids of the two amplifying systems does not vary.

The operation of the circuit arrangement may be explained as follows. The alternating screen-grid current of the upper amplifying system causes a voltage drop across the resistance 13 as a result of which the screen-grid of the upper amplifying system exhibits an alternating voltage with respect to the cathode, which alternating voltage is in phase-opposition to the alternating control-grid voltage of the upper amplifying system so that it is in phase with the alternating control-grid voltage of the bottom amplifying system. This voltage evolves current through the capacity 15 to the control-grid of the bottom amplifying system, which current leads by 90° relatively to the voltage of this control-grid, so that it causes an apparent decrease in capacity of this control-grid relatively to the cathode. The voltage across the resistance 13 and consequently also the apparent decrease in input-capacity of the bottom amplifying system is proportional to the mutual conductance of the upper amplifying system. Since to a first approximation the input-capacity increases linearly with the mutual conductance during control, correct proportioning permits the variation of the input-capacity of the bottom amplifying system to be made up for as a result of the cooperation referred to above between the resistance 13 and the capacity 15. Similarly the variation of the input-capacity of the upper amplifying system is compensated by cooperation between the resistance 14 and the capacity 16.

The circuit-arrangement represented in Fig. 2 differs from that shown in Fig. 1 in that the resistances 13 and 14 are inserted in the alternating current-conveying part of the anode circuits of the amplifying systems. For this purpose the output-oscillatory circuit 7 is divided into two parts 17 and 18, the resistances 13 and 14 being provided between these parts. The connecting point of the resistances 13 and 14 is connected through condensers 8 and 4 to the cathodes, the screen-grids being directly connected for high frequencies to the cathodes through the condenser 4.

In the circuit shown in Fig. 3 the resistances 13 and 14 are inserted both in the anode-circuit and in the screen-grid circuit of the amplifying systems. To this end the screen-grids are connected through condensers 4' and 4" to the ends of the resistances 13 and 14 facing the anodes, in which case the resistances are traversed both by the anode-current and by the screen-grid current of the amplifying system in question.

Fig. 4 shows a circuit in which the function of condensers 15 and 16 is fulfilled by the natural screen-grid-control-grid capacitances of the amplifying systems, which capacities are indicated in dotted lines in the drawings. In this case the resistances 13 and 14 are inserted in the anode-circuit and the end of resistance 13 facing the anode is connected through the condenser 4' to the screen-grid of the bottom amplifying system, whereas the end of the resistance 14 facing the screen-grid of the upper amplifying system. The resistance 13 is traversed by the anode-current of the upper amplifying system less the screen-grid current of the bottom amplifying system, the current flowing through the resistance 14 corresponding to the anode-current of the bottom amplifying system less the screen-grid current of the upper amplifying system.

In the circuits represented in Figures 2, 3 and 4, where the resistances 13 and 14 are located in the anode-circuits of the amplifying systems, these resistances may also be constituted by a part of the output-oscillatory circuit.

Fig. 5 represents a circuit-arrangement embodying this principle, In this case the screen-grids of the amplifying systems are connected to tappings 17 and 18 of the output-oscillatory circuit 7, the part of the circuit 7 between the tapping 17 and the center playing the part of resistance 18, and the part located between the tapping 18 and the center playing the part of resistance 14. Otherwise the circuit entirely corresponds to that shown in Fig. 3.

Fig. 6 represents a circuit deduced in a similar manner from the circuit shown in Fig. 4. In this case the screen-grid of the upper amplifying system is connected to the tapping 10, and the screen-grid of the bottom amplifying system is connected to the tapping 17.

The circuits represented in Figures 5 and 6, in which the ohmic resistances required for compensation are constituted by a part of the output-oscillatory circuit are somewhat simpler than those shown in Figures 1 to 4, but they may sometimes exhibit the drawback of the reaction of the output-circuit on the input circuit being too strong.

In amplifying very high frequencies, when the alternating currents of the anode and the screen-grid exhibit a considerable phase displacement relatively to the alternating control-grid voltage, this phase displacement can be made up for by replacing the resistances 13 and 14 by impedances having such a phase-angle that the voltage set up across these impedances has the phase required for the desired compensation.

What we claim is:

1. A high-frequency amplifying circuit comprising two push-pull connected similar electrode systems each having a cathode, a signal control grid and at least two cold electrodes, the cathodes of the two systems having a direct connection between them, means for applying a variable negative bias potential to the signal control grid for varying the amplification of the circuit, a pair of resistances, unbypassed for high frequencies, included in the alternating current paths of at least two of the corresponding cold electrode circuits, one end of each resistance being connected for high frequencies to the cathodes, and a pair of capacities each connected between the other end of one of said resistances and the control grid of the electrode system other than the one including the cold electrode to which said one resistance is connected, said resistances and capacities being so proportioned.
as to substantially compensate for the variation of the input-capacity of the circuit which occurs during amplification control.

2. A high-frequency amplifying circuit as defined in claim 1 wherein the two cold electrodes of each system comprise a screen grid and an anode.

3. A high-frequency amplifying circuit as defined in claim 1 wherein the two cold electrodes of each system comprise a screen grid and an anode, and the pair of resistances are included in the alternating current paths of the screen grid circuits.

4. A high-frequency amplifying circuit as defined in claim 1 wherein the two cold electrodes of each system comprise a screen grid and an anode, and the pair of resistances are included in the alternating current paths of the anode circuits.

5. A high-frequency amplifying circuit as defined in claim 1 wherein the two cold electrodes of each system comprise a screen grid and an anode, and the pair of resistances are included in the alternating current paths of both the screen grid and anode circuits.

6. A high-frequency signal-translating stage comprising a vacuum tube provided with two similar electrode systems, each including a cathode, a signal control grid and at least two positive cold electrodes, the cathodes being connected together by a lead as short as possible, an input circuit connected in push-pull to the signal control grids, means for applying an adjustable negative bias potential to said control grids to vary the transconductance of each electrode system, said variation in bias potential having a tendency to vary the input capacitance of the tube, and means to compensate for such variation in input capacitance, said compensating means comprising an impedance connected for high frequency between at least one of the cold electrodes of each system and the common cathode lead, and a pair of capacities cross-connected from each end of the impedance connected to the cold electrode of one electrode system to the signal control grid of the other electrode system.

7. A high-frequency signal-translating stage comprising a vacuum tube provided with two similar electrode systems, each including at least a cathode, a signal control grid, a screen grid and an anode, the cathodes being connected together by a lead as short as possible, an input circuit connected in push-pull to the signal control grids, means for applying an adjustable negative bias potential to said control grids to vary the transconductance of each electrode system, said variation in bias potential having a tendency to vary the input capacitance of the tube, and means to compensate for such variation in input capacitance, said compensating means comprising a resistance connected for high frequency between each screen grid and the common cathode lead, and a pair of capacities cross-connected from the screen grid end of the resistance connected to the screen grid of one electrode system to the signal control grid of the other electrode system.