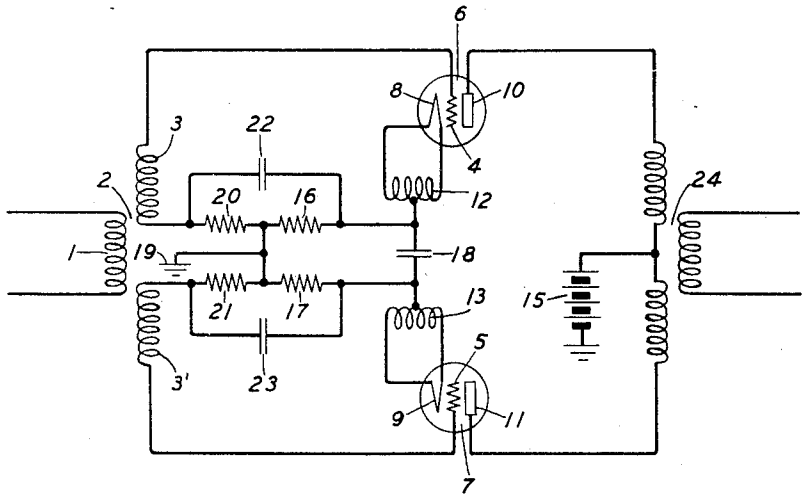
Aug. 29, 1933. V. M. COUSINS 1,924,836

AMPLIFIER

Filed Sept. 30, 1932



INVENTOR
V. M. COUSINS
BY H. A. Burgess
ATTORNEY

Patented Aug. 29, 1933

1,924,836

UNITED STATES PATENT OFFICE

1,924,836

AMPLIFIER

Van M. Cousins, Lyndhurst, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a Corporation of New York

Application September 30, 1932
Serial No. 635,477

6 Claims. (Cl. 179—171)

This invention relates to amplifiers using space discharge devices and more especially to amplifiers in which the devices are arranged in push-pull or balanced relation.

In amplifiers using space discharge devices including grid, cathode and anode, the grid bias is often obtained from an impedance inserted in the anode circuit of the device. McNally Patent 1,848,187, March 8, 1932, shows how independent resistors in the anode circuits improve the operation and balance of such circuits when applied to devices arranged in push-pull or balanced relation.

The present invention has as an object the improvement of the operation of amplifiers involving circuits of the type noted.

More specifically it is an object of this invention to improve the response of balanced amplifiers at low frequencies.

Another object is to control the regenerative effects of even order products of modulation or parallel singing to the point of practical elimination, in amplifiers of the balanced type.

A feature of the invention is a single capacity connected between the cathodes of the space discharge devices of a balanced amplifier in shunt to the bias resistors.

Another feature of the invention is a filter comprising a resistance and capacity, for each biasing resistor whereby the regenerative effects of even order products of modulation may be reduced or substantially eliminated from the circuits of the space discharge devices connected in balanced relation.

It is desired to point out that whereas the description which follows is written from the standpoint of degeneration of second order products of modulation by a proper choice of the resistance and capacity making up the so-called filter, a phase shift of the feedback voltage may be obtained which will produce positive regeneration at low frequencies.

The invention, together with additional objects and features, will be better understood from the following description and attached drawing forming a part thereof which is a diagrammatic sketch of a preferred form of the invention.

Referring now to the drawing, an input transformer 2 having a primary winding 1 and a secondary winding comprising two parts 3 and 3' is shown with the outside terminals of the secondary winding connected to the grids 4 and 5 of space discharge devices 6 and 7.

The primary winding 1 of transformer 2 may be connected to any source, the output of which is to be amplified such as a preceding amplifier stage, a microphone, a telephone line, a radio receiving system, a phonographic record pick-up, etc.

Devices 6 and 7 are illustrated as of the type in which alternating current is directly applied to the cathodes or filaments from respective secondary windings 12, 13 of filament heating transformers. It is to be understood, however, that the invention is applicable to devices with direct current heating source or to the heater type device which has gone into considerable use. The primary winding of the cathode heating transformer has not been shown as the arrangement is believed well known.

Anode current is obtained from source 15, illustrated as a battery, but this source may be any direct current source such as rectified alternating current.

The individual biasing resistors are shown at 16 and 17 shunted by condenser 18.

Associated with biasing resistors 16 and 17 are filters comprising resistances 20, 21 and condensers 22 and 23. The common ground point of the input circuit is at 19.

An output transformer 24 having a divided primary winding is connected in the well known manner to the anodes 10 and 11, and its mid-point connected to source 15. The secondary winding of transformer 24 may be connected to any utilization circuit.

The input circuits of the amplifier may be traced from ground 19, resistances 20 or 21, secondary windings 3 or 3', grids 4 or 5, cathodes 8 or 9, grid bias resistors 16 or 17 to ground 19.

The anode circuits may be traced from grounded source 15, mid-point of primary winding of transformer 21 through each half of this winding to the anodes 10 and 11, cathodes 8 and 9, resistors 16 and 17 to ground at 19. The IR drop of the anode current through resistors 16 and 17 provides the bias for the grids 4 and 5 in a well known manner.

It will be noted that the bias resistors are common to the grid and anode circuits of each of the devices 6 and 7. They are also common to the input and output circuits of the amplifier considered as a unit. Now since the signal voltage in the anode circuit is in phase opposition to the signal voltage in the grid circuit unless some means were provided to suppress in the grid circuits the signal voltages derived from the anode circuits due to the drop of potential across the resistors 16 and 17, there would be a reduction in the amplifier gain. Condenser 18 offers a path of

low impedance at the signal frequency across the two bias resistors 16 and 17 in series and thus effectively prevents voltages of the signal or other desired frequencies from being impressed on the grids from across these bias resistors. The individual grid filter condensers 22, 23 tend to suppress signal frequencies from the grid circuits but their action is supplemented by condenser 18 which directly shunts the bias resistors together with the grid filters.

As is well known in circuits of the type herein described second order products of modulation occur in the individual circuits of the space discharge devices but not in the circuit of the amplifier as a whole. To reduce or substantially eliminate the degenerative effects of these second order products, the filter consisting of resistance 20 and capacity 22 in the one case and resistance 21 and capacity 23 in the second case are provided, the capacities and resistances are chosen of such value that the degenerative effects of the even order products may be practically completely eliminated and hence do not interfere with the proper amplification of the desired frequencies.

It is found that by controlling the capacities 22, 23 and 18 in relation to the resistances 20 and 21, a change in phase of the signal frequencies, especially the lower frequencies, can be affected so as to modify the action and in some cases actually cause an aiding feedback so as to increase amplification. With condenser 18 absent this effect is also obtainable by varying capacities 22, 23 in relation to resistances 20 and 21.

It is to be understood that whereas the invention has been described in connection with but one embodiment, it is to be limited only by the scope of the appended claims.

What is claimed is:

1. An amplifier comprising space discharge devices arranged in push-pull relation, individual grid bias resistors in the anode circuits of said devices and a two-terminal impedance connected between the cathodes of said devices short circuiting said resistors for alternating current of the frequency to be amplified.

2. In an amplifier, space discharge devices arranged in balanced relation and a condenser connecting the cathodes of said devices of such capacity as to be of negligible impedance to alternating currents of the frequency to be amplified.

3. In an amplifier, space discharge devices arranged in balanced relation, a common source of anode current, individual grid bias resistors in the anode circuits connecting the cathodes of the devices to the negative terminal of the anode current source and to the grids of the devices and a condenser of small impedance to alternating currents of the frequency to be amplified, as compared to that of said resistors, in shunt to said resistors.

4. In an amplifier comprising space discharge devices arranged in push-pull relation, a space current source, input and output circuits for said devices, a part of each input and output circuit being common and comprising a resistance element, said resistance elements at one end being each connected to the negative pole of the space current source and a two-terminal impedance connected between the opposite ends of said resistance elements to by-pass the electrical waves to be amplified around said resistance elements.

5. An amplifier comprising space discharge devices arranged in push-pull relation, individual grid bias resistors in the anode circuits of said devices, unitary means short circuiting said resistors for alternating currents of the frequency to be amplified, and individual resistance capacity filters comprised in part of said resistors for preventing application to the grids of undesired frequency components.

6. In a push-pull amplifier comprising a pair of space discharge devices each having a cathode, an anode and a grid or control element, individual grid-to-cathode circuits, each including a grid bias resistor, a connection from said resistors to the negative pole of the plate potential source, a connection from each resistor to its corresponding grid, means including an individual condenser shunting each of said resistors, and a condenser connected directly between the cathodes, each of said condensers offering negligibly low impedance to currents of the frequency to be amplified.

VAN M. COUSINS.