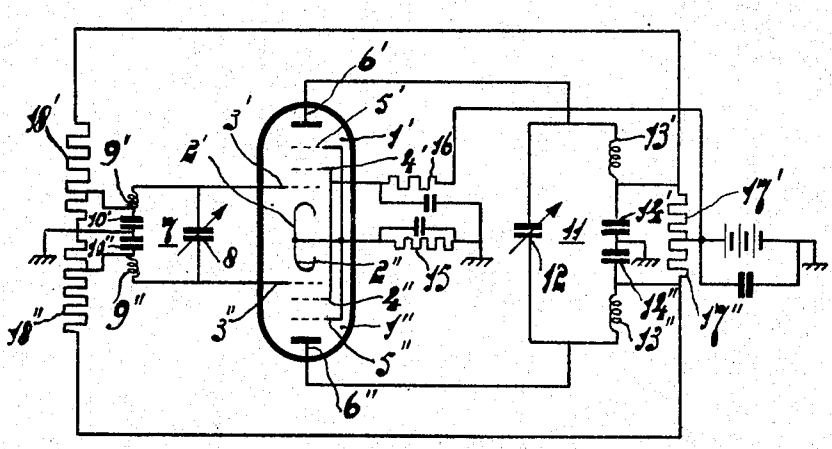
Nov. 4, 1952 K. RODENHUIS 2,616,988

SELF-BALANCING PUSH-PULL AMPLIFIER

Filed May 2, 1947



K. RODENHUIS
INVENTOR
BY
ATTORNEY

Patented Nov. 4, 1952 2,616,988

UNITED STATES PATENT OFFICE

2,616,988

SELF-BALANCING PUSH-PULL AMPLIFIER

Klaas Rodenhuis, Eindhoven, Netherlands, assignor to Hartford National Bank and Trust Company, Hartford, Conn., as trustee

Application May 2, 1947, Serial No. 745,616
In the Netherlands March 30, 1946

Section 1, Public Law 690, August 8, 1946
Patent expires March 30, 1966

2 Claims. (Cl. 179—171)

1

This invention relates to a circuit-arrangement for the transmission of electrical oscillations, more particularly of intermediate frequency and/or high-frequency oscillations, by means of at least two push-pull connected discharge systems, notably two discharge systems housed in a single bulb, of which the cathodes and the screen-grids, if any, are directly interconnected in pairs inside the bulb.

In the case of low-frequency push-pull amplifiers it is known to improve the equality of the direct current loads of the two discharge tubes used in the amplifier by causing each tube to produce its own grid bias, namely by causing the anode current to bring about a voltage drop across a resistance included in the cathode lead.

It is also known to attain the aforesaid object by including a resistance in the screen-grid circuits of each of the tubes.

These known methods, however, cannot longer be used if the two push-pull discharge systems are housed in a single bulb, since in this case, as a rule, the cathodes are interconnected within the bulb in order to minimize the inductance of the cathode-lead, which is advantageous in transmitting ultra-short waves. In this case it frequently occurs, moreover, that the screen-grids are likewise directly interconnected inside the bulb, this having under certain circumstances the advantage of permitting the cathodes of the two discharge systems to be placed more closely together, so that this measure also yields a lower inductance of the cathode-lead. Direct interconnection of the screen-grids is sometimes even necessary viz. if, in the case of short waves, there occurs resonance between the inductances of the screen-grid leads and the screen-grid capacities.

In these cases the conventional circuit-arrangements cannot be used any longer, since the use of these circuit-arrangements requires the cathodes and the screen-grids respectively to be provided separately.

The invention provides a circuit-arrangement which also automatically ensures equal or substantially equal direct current loads of the two discharge systems, and which is also adapted to be used when the known circuit-arrangements are no longer serviceable for the aforesaid reasons. Under certain conditions the circuit-arrangement according to the invention yields better results than the known circuit-arrangements.

According to the invention each of the anode circuits of the discharge systems includes a resistance and each of the direct voltages set up across these resistances and varying with the

2

value of the anode current is entirely or partly supplied to a control-grid of the corresponding discharge system in such manner that equal or substantially equal direct current loads of the discharge systems are automatically ensured.

As a rule the direct voltages are each supplied, through one or more resistances, to the corresponding control grids.

Each of the aforesaid direct voltages is preferably supplied to a control-grid of the corresponding discharge system through a potentiometer which is connected between the anode and the junction of the cathodes or a point of constant potential (earth).

The undue positive nature of the voltage thus set up at the control-grids may be eliminated by inserting a resistance in the common cathode-lead of the two discharge systems, for example, between the junction of the cathodes and the interconnected ends of the aforesaid potentiometers, the said resistance being proportioned in a manner such that the desired negative bias is set up at the control-grids of the discharge systems.

In order that the invention may be clearly understood and readily carried into effect, it will now be described more fully with reference to the accompanying drawing, in which one form of construction of the circuit-arrangement according to the invention is represented by way of example.

This drawing represents a circuit-arrangement for amplifying high-frequency oscillations by means of two push-pull connected discharge systems 1', 1'', each comprising a cathode 2', 2'', a control-grid 3', 3'', a screen-grid 4', 4'', a suppressor 5', 5'' and an anode 6', 6'' respectively. The two systems 1', 1'' are housed in a single bulb. The suppressor grids 5', 5'', screen-grids 4', 4'' and cathodes 2', 2'' are interconnected in pairs inside the bulb, the suppressor grids being, moreover, directly connected to the cathodes. The two discharge systems may be so constructed as to have a common cathode.

A push-pull circuit 7, which is tuned to the frequency of the oscillations to be amplified, is connected between the control grids 3' and 3''. This circuit comprises a variable condenser 8 and two coils 9', 9'', the latter being interconnected through the series-connection of two blocking condensers 10', 10''.

The amplified oscillations may be obtained from an output circuit 11 connected in push-pull arrangement between the anodes 6', 6''. The push-pull circuit 11 is composed in the same

manner as the input circuit 7 and is constituted by a variable condenser 12, two coils 13', 13'' and two blocking condensers 14', 14''. The centre of the push-pull circuits 7 and 11 (the junction of the blocking condensers 10', 10'' and 14', 14'' respectively) is earthed.

The cathode-lead includes a resistance 15 and the screen-grid circuit comprises a resistance 16.

The circuit-arrangement so far described suffers, in general, from the drawback that very different anode currents flow through the two discharge systems 1' and 1'', since, owing to small disparities in construction, in contact potentials or in mutual conductances, the location of the working point of each discharge system may slightly vary. This is often undesirable, particularly if stringent requirements are imposed on the equilibrium of the output signal. It is therefore desirable to construct the push-pull circuit-arrangement in such manner that anode-current differences are automatically neutralized.

However, the conventional circuit-arrangements used for this purpose cannot be used in the present case, since in these circuits use is made of the cathode-leads and the screen-grid leads respectively of each of the discharge systems, in contradistinction to the circuit-arrangement according to the invention, which may also be used in the present case and which, under certain conditions, ensures even a greater equality of the direct current loads of the two discharge tubes than the known circuits.

According to the invention each of the anode circuits includes a resistance 17', 17'', at which direct voltages are set up which depend upon the anode current in question. Part of the direct voltage set up across resistance 17' and 17'' respectively is supplied to the control-grid 3' and 3'' respectively through a potentiometer 18' and 18'' respectively.

The circuit-arrangement operates as follows: If for some reason the anode current of any of the discharge systems should exceed its normal value, the anode voltage falls off. Owing to this the potential of the associated control-grid decreases, so that the increase in anode current is counteracted by the decrease in control-grid voltage.

A simple calculation proves that by the circuit-arrangement any anode current variations (which may, for example, occur upon interchanging the discharge systems) are reduced to a fraction designated f of the initial value, f being equal to

$$\frac{1}{1+pRS}$$

in which S represents the mutual conductance of the discharge system, R the value of the resistance in the anode circuit and p the potentiometer ratio.

In this case the circuit-arrangement automatically seeks to maintain the anode current value once adjusted.

The potentiometer sets up a positive voltage at the control-grid. In order to ensure that the control-grid has the required negative bias relatively to the cathode, the common cathode-lead includes the aforesaid resistance 15, through which the two anode currents flow. The resistance 15 has such a value that the voltage drop across this resistance sets up a positive potential at the cathode, which is so much higher than that of the control-grids relatively to earth that the latter acquire the customary negative bias for the normal working point.

From the aforesaid expression it appears that the neutralization of the relative difference in value of the anode currents will be better as the value of resistance R is higher and as the potentiometer ratio nears unity. The value of the available supply voltages determines what values of R and p are permissible. The circuit-arrangement will be more fully explained by giving a numerical example.

The elements of the circuit-arrangement as shown in the drawing, inasmuch as they are essential to the invention, have the following values:

$R_{17'}=R_{17''}=2500$ ohms
$R_{18'}=R_{18''}=550{,}000$ ohms
$p=0.1$
$R_{15}=1150$ ohms
$R_{16}=1700$ ohms

the supply voltage being 300. The data of the discharge systems used are:

$Va=Vg_2=250$ volts
$-Vg_1=2$ volts
$Ia=10$ ma.
$Ig_2=1.8$ ma.
$S=6$ ma./volt

Two sets (A and B) of these discharge systems are successively connected in push-pull arrangement in the usual manner, i. e. without making use of the invention, the following anode-current strengths being measured:

In the case A: $Ia_1=13.6$ ma.; $Ia_2=4.4$ ma.
In the case B: $Ia_1=8.5$ ma.; $Ia_2=6.9$ ma.

Thereupon the same sets of discharge systems are used in the circuit-arrangement according to the invention, the measuring results being:

A: $Ia_1=11.9$ ma.; $Ia_2=10.2$ ma.
B: $Ia_1=11.5$ ma.; $Ia_2=9.9$ ma.

Thus it is evident that the anode currents of the push-pull connected discharge systems have become substantially equal. In one case the factor f has a value of 0.25, i. e. twice as low as that generally obtained in the conventional circuit-arrangement comprising resistances in the screen-grid circuits, which means that the circuit-arrangement operates twice as effectively.

What I claim is:

1. A push-pull amplifier comprising a pair of electron-discharge systems included in a common envelope, each system having a cathode, a grid and an anode, the cathodes of said systems being directly interconnected within said envelope; a push-pull input circuit including a condenser connected between the grids of said systems, a pair of inductors and a pair of by-pass capacitors, one end of each inductor being connected to a respective grid, the by-pass capacitors being connected in series between the other ends of said inductors, the junction of said by-pass capacitors being grounded; a push-pull output circuit including a condenser connected between the anodes of said systems, a pair of inductances and a pair of by-pass capacitances, one end of each inductance being connected to a respective anode, said by-pass capacitances being connected in series between the other ends of said inductances, the junction of said by-pass capacitances being grounded, means to couple said interconnected cathodes to ground, a pair of resistors serially connected across said series connected by-pass capacitances, means to apply a positive potential relative to ground to the junction of said resistors, whereby a voltage is developed across each re-

sistor proportional solely to the direct current flow therethrough, and means coupled to each resistor to apply the voltage thereacross to a respective grid to maintain substantially equal direct currents in said systems.

2. An arrangement, as set forth in claim 1, wherein said means to apply the voltages across said resistors to said grids is constituted by a pair of potentiometers, each having a tap, said potentiometers being connected in series across said serially connected resistors, the tap of each potentiometer being connected to a respective grid, the junction of said potentiometers being grounded.

KLAAS RODENHUIS.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,998,479	Wise	Apr. 23, 1935
2,123,241	Harley	July 12, 1938
2,154,200	Dow	Apr. 11, 1939
2,157,870	Sowers	May 9, 1939
2,300,133	Nyquist	Oct. 27, 1942