PATENT SPECIFICATION

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PROVISIONAL SPECIFICATION

Improvements in and relating to Thermionic Valve Circuits of the Push-pull Type

I, HORACE DUDLEY MCDONOGH ELLIS, a British Subject, of 42, Marlpit Lane, Coulsdon, Surrey, do hereby declare the nature of this invention to be as follows:—

The present invention relates to thermionic valve circuits of the push-pull type and is concerned with the provision of novel and simple means whereby, without the need for a tapped transformer, there can be obtained from an input in the form of potential variations which are always in the same sense with respect to a neutral point, an output such that the potential of one of two output terminals changes in phase opposition to that of the other output terminal with respect to the same neutral point.

According to the present invention, there is provided a circuit comprising two thermionic valves having their anodes connected to the positive terminal of a source of anode voltage in push-pull relationship and having their cathodes connected through a common impedance to the negative terminal of said source, input terminals being connected respectively to the control grid of one of the valves and a point on the said impedance, and the control grid of the second valve being connected to the same or a different point on the said impedance.

In carrying the invention into effect I may proceed as follows:—

Two pentode valves are arranged with their anodes connected to opposite ends of the primary winding of an output transformer, the centre point (or other suitable intermediate point) on the winding being connected to the positive terminal of a source of high tension anode voltage. The cathodes of the two valves are connected together and through a cathode circuit resistance to the negative terminal of the source. The screen grids of the valves are connected together and through a decoupling resistance to the positive terminal of the source, a decoupling condenser being connected from the screen grids to the cathodes. The suppressor grids are connected to the cathodes.

One of two input terminals is connected through a condenser to the grid of one of the valves which will be referred to for clearness as the first valve and the other input terminal is connected to the negative terminal of the source. A grid leak is connected from the grid of the first valve to the negative terminal of the source. The grid of the second valve is also connected to the negative terminal of the source.

The first valve is arranged to operate as a cathode follower: that is, to say the cathode potential is arranged, by negative feed-back due to the presence of the cathode circuit resistance, to vary in the same sense as the control grid potential. If the cathode circuit resistance is made large compared with the reciprocal of the mutual conductance of the valve, the variation of potential of the cathode will be approximately of the same magnitude, as well as of the same sense, as that of the control grid relative to earth. The cathode potential must, however, always vary less than the control grid potential. Thus with a cathode circuit resistance of 1000 ohms approximate equality of voltage change is obtained when the mutual conductance equals 0.01 amps per volt.

Now, in operation, both valves obtain grid bias from the potential drop across the cathode circuit resistance which is common to both anode circuits and the value of the resistance has therefore to be chosen so as to yield the desired bias. Assuming for the sake of simplicity that the negative terminal of the source, and hence the grid of the second valve, is earthed, the potential of this grid will remain at zero. In the absence of a signal, therefore, the potential relative to earth of the grid of the first valve will be zero and that of the cathodes will be say 2 volts positive.

If a signal makes the grid of the first valve say 1 volt positive relative to earth, the potential of the cathodes may change from 2 volts positive to some value between 2 and 3 volts positive. The effective grid-cathode potential difference of the first valve has therefore been reduced and that of the second valve has been increased:

[*Price* 1/-]

that is the changes in the two valves are in opposite senses and a push-pull output is therefore obtained.

It is to be noted that the cathode circuit resistance is traversed in the same sense by the steady anode currents of the two valves but in opposite senses by the signal components of the anode current. In other words if equal changes in anode current takes place in the two valves for a given input, there would be no change in the current through the resistance. This means that the second valve would in fact obtain no drive because in the circuit above described the variations applied to the control grid circuit of the second valve are obtained from changes in potential drop across the resistance.

In order that the circuit described may operate therefore it is necessary that there should be some asymmetry in the voltages applied in the control grids of the two valves, or that they should have different mutual conductances, so that there may be differences in the changes in anode current.

Since the second valve is dependent for its drive upon the difference in anode currents, the cathode circuit resistance which has a suitable value from the point of view of grid bias for the two valves will usually be too small to give an adequate drive to the second valve.

If desired, therefore, the resistance may be given a value which is unduly high from the point of view of grid bias and the negative bias applied to the grids may then be reduced to suitable values by the insertion of suitable batteries. The value of the cathode circuit resistance will, however, normally be made small compared with the impedances of the valves and compared with the impedances of the inter-electrode capacities of the valves at the highest operating frequencies.

In a modification of the above described circuit, which is at present the preferred arrangement, however, the negative terminal of the source, instead of being directly connected to the cathode circuit resistance, the one input terminal and the grid of the second valve, is connected to the cathode circuit resistance and to the input terminal through a further resistance and to the grid of the second valve through a condenser. The grid of the second valve is then connected to the above mentioned input terminal by a grid leak.

The cathode circuit resistance is given a value suitable for grid bias purposes and may be say 100 ohms and the further resistance may have a value of say 1000 ohms. In this way the drive for the second valve is derived from changes in potential across the two resistances in series; in the example given a total of 1100 ohms.

Dated this 4th day of January, 1937.

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COMPLETE SPECIFICATION

Improvements in and relating to Thermionic Valve Circuits of the Push-pull Type

I, HORACE DUDLEY MCDONOGH ELLIS, a British Subject, of 42, Marlpit Lane, Coulsdon, Surrey, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

The present invention relates to thermionic valve circuits of the push-pull type, and is concerned with the provision of novel and simple means whereby, without the use of a tapped transformer, there can be obtained from an input in the form of potential variations which are always in the same sense with respect to a neutral point, an output such that the potential of one of two output terminals changes in phase opposition to that of the other output terminal with respect to the same neutral point.

The present invention provides a circuit arrangement comprising two thermionic valves each having a cathode, an anode and a control grid, and a transformer for coupling the anodes of said valves to an output circuit in push-pull relation with respect to a terminal for connection to the negative pole of an anode current source, wherein the two cathodes are connected to said terminal through a common impedance capable of passing direct current, input terminals being connected respectively to the control grid of one of the valves and to a point on said impedance, and wherein a connection is provided from the control grid of the other valve to a point on said impedance such that potential differences set up across said impedance appear in the control grid-cathode circuit of the said other valve.

Reference will now be made to the accompanying drawing, of which Figs. 1 and 2 show, by way of example, two embodiments of the invention. Like re-

ferences are used in the two Figures for similar parts.

Referring to Fig. 1, two valves 3 and 4 are arranged with their anodes connected to opposite ends of the primary winding 5 of an output transformer 6, the centre point (or other suitable intermediate point) on the winding 5 being connected to the positive terminal 7 of a source (not shown) of anode current. The cathodes of the two valves are connected together and through a cathode circuit resistance 8 to the negative terminal 9 of the source. Although the two valves are shown as pentodes, it will be clear that the invention is not limited to the use of pentodes, and triodes or tetrodes, for example, may be employed if desired. The screen grids of the valves are connected together and through a decoupling resistance 10 to the positive terminal 7 of the anode current source, a decoupling condenser 11 being connected between the screen grids and the cathodes. The suppressor grids are connected to the cathodes.

An input terminal 12 is connected through a condenser 13 to the grid of the valve 3, and a second input terminal 14 is connected to the negative terminal 9 of the anode current source. A grid leak 15 is connected from the grid of the first valve 3 to the negative terminal 9, and the grid of the valve 4 is connected directly to the negative terminal 9.

Because of the presence of the resistance 8 in the cathode circuit of valve 3, the cathode potential of valve 3, in the presence of an oscillation applied at terminals 12 and 14, tends to vary in the same sense as the control grid potential thereof relative to the negative terminal 9 of the anode current source. The magnitude of the cathode potential changes is always less than the magnitude of the grid potential changes, but the difference can be made small by making the resistance 8 large compared to the reciprocal of the mutual conductance of valve 3. Potential differences set up across resistance 8 are applied between the control grid and cathode of valve 4 in such a sense that the resultant anode current in valve 4 is in opposite phase to that in valve 3, and the outputs of the two valves are thus in push-pull relationship. This will be clear from the following explanation:

The grid of valve 4 is connected directly to the terminal 9, and can be regarded as remaining at zero potential. In the absence of applied oscillations at terminals 12 and 14, the potential of the control grid of valve 3 is also zero, and the cathodes of both valves are, say, at 2 volts positive. If now an oscillation applied to terminals 12 and 14 makes the control grid of valve 3 one volt positive relative to terminal 9, the cathode potential will increase to some potential greater than 2 volts but less than 3. The effective grid-cathode potential difference of valve 3 is thus reduced, whereas that of valve 4 is increased; that is, the two valves are driven in push-pull.

It is to be noted that the cathode circuit resistance 8 is traversed in the same sense by the steady anode currents of the two valves, but in opposite senses by the signal components of the anode currents. In other words, if equal changes in anode current were to take place in the two valves for a given input, there would be no change in the current through the resistance 8; this means that the valve 4 would in fact obtain no drive, because the potential variations applied to the control grid circuit of the valve 4 are those due to changes in current in resistance 8.

In order that the circuit described may operate, therefore, it is necessary either that there should be some asymmetry in the voltages applied in the control grids of the two valves, or that they should have different mutual conductances, so that there may be differences in the anode currents in resistance 8.

It will be noticed that both valves obtain control grid bias from the resistance 8, which passes a steady current equal to the sum of the currents leaving the cathodes of the two valves and flowing to terminal 9. In practice, it may be found that the value of resistance necessary to furnish the required bias may be too small to give an adequate drive for valve 4; that is, the drive applied to valve 4 may be so much below that necessary for full output from this valve that the arrangement is inefficient.

If desired, therefore, the resistance 8 may be given a value which is unduly high from the point of view of grid bias, and the excessive grid bias may then be reduced to a suitable value by the insertion of suitable batteries, or by other known equivalent means. The value of the cathode circuit resistance 8 is, however, normally made small compared with the impedances of the valves 3 and 4, and compared with the impedances of the inter-electrode capacities of the valves at the highest operating frequencies. If desired, also, the resistance 8 may be replaced by a choke coil, by a choke coil in series with a resistance or by any other desired impedance capable of passing direct current.

In the arrangement of Fig. 1, the resistance 8 serves to furnish negative feedback into the control grid circuit of valve 3; this is not an essential feature, and the input terminal 14 may if desired

be connected to the upper end of resistance 8 instead of to the lower end thereof.

A modification of the above-described circuit, which is at present the preferred arrangement, is shown in Fig. 2. In this embodiment, the negative terminal 9 of the anode current source, instead of being directly connected to the cathode circuit resistance 8, the input terminal 14 and the grid of the valve 4, is connected to the cathode circuit resistance 8 and to the input terminal 14 through a further resistance 16, and to the grid of the valve 4 through a condenser 17. The grid of the valve 4 is connected to the input terminal 14 through a grid leak 18.

The cathode circuit resistance 8 is given a value suitable for grid bias purposes, say 100 ohms.

The further resistance 16 may then have a value as large as is convenient, say 1000 ohms. In this arrangement, the drive for the valve 4 is derived from changes in potential across the two resistances 8 and 16 in series, a total resistance of 1100 ohms, but the effective biasing resistance is only 100 ohms.

The input terminal 14 may be connected to the top of resistance 8 instead of to the bottom as shown. In another modification of the arrangement of Fig. 2, resistance 16 is removed so that terminals 9 and 14 are connected together, and the resistance 16 is replaced in a position between the tap 5 in the primary winding of transformer 6, and the terminal 7; the lower end of condenser 17 is then connected to terminal 7 instead of to terminal 9.

The invention is applicable for use in high-frequency as well as in low-frequency circuits.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. A circuit arrangement comprising two thermionic valves each having a cathode, an anode and a control grid, and a transformer for coupling the anodes of said valves to an output circuit in push-pull relation with respect to a terminal for connection to the negative pole of an anode current source, wherein the two cathodes are connected to said terminal through a common impedance capable of passing direct current, input terminals being connected respectively to the control grid of one of the valves and to a point on said impedance, and wherein a connection is provided from the control grid of the other valve to a point on said impedance such that potential differences set up across said impedance appear in the control grid—cathode circuit of the said other valve.

2. A circuit arrangement according to claim 1, wherein said impedance comprises two resistances in series, the control grids of the two valves being connected to the same or different points on the two resistances through different leak resistances.

3. A circuit arrangement according to claim 2, wherein the control grid of the valve other than that to which input potential differences are applied is connected through a condenser to the terminal for connection to the negative pole of an anode current source.

4. A circuit arrangement substantially as herein described with reference to Fig. 1 or Fig. 2 of the accompanying drawing.

Dated this 21st day of December, 1938.

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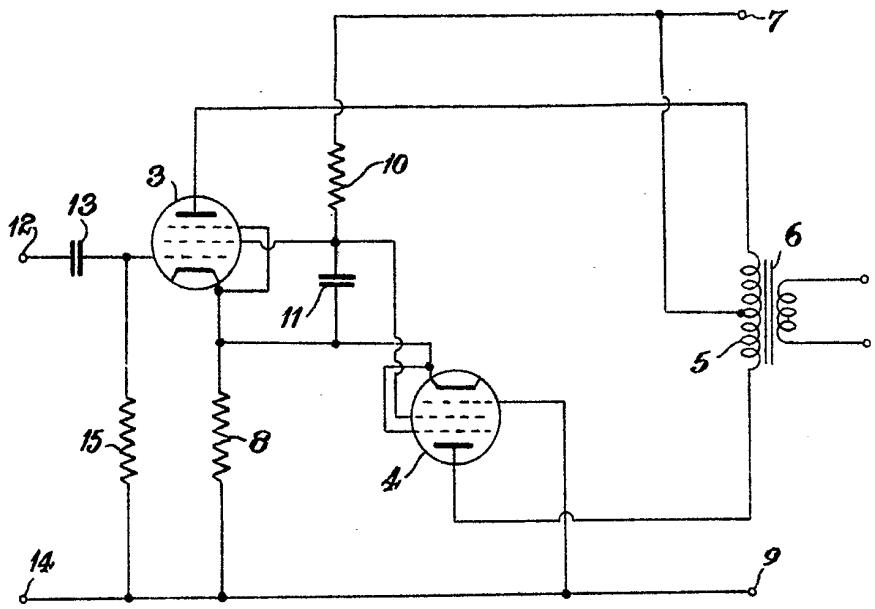

Fig. 1.

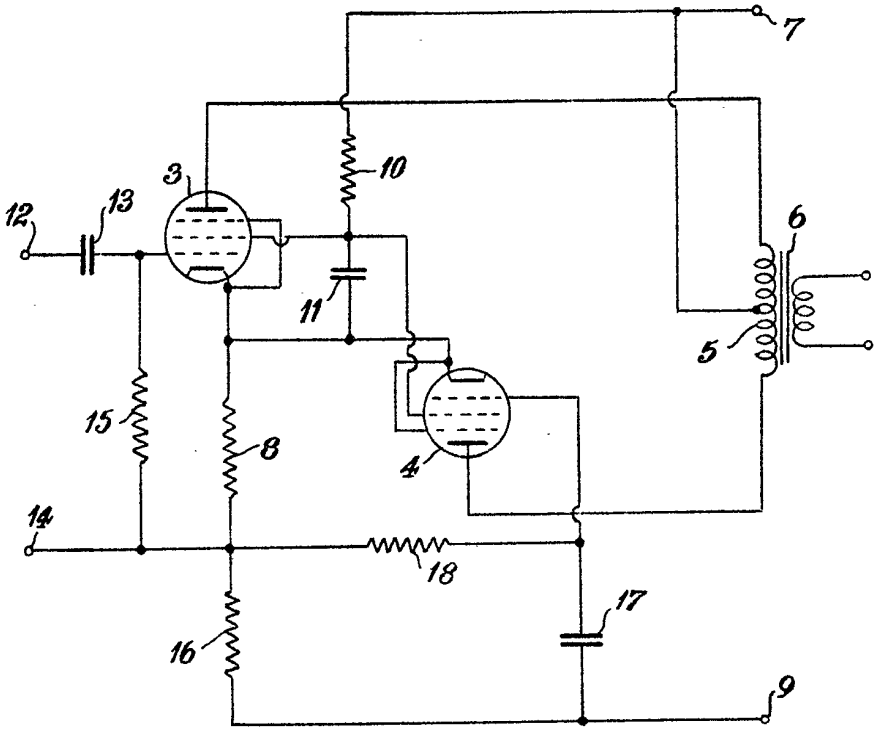

Fig. 2.

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