June 13, 1939. J. RUSTON 2,162,389

PUSH-PULL AND LIKE AMPLIFYING SYSTEMS

Filed Aug. 6, 1936 2 Sheets-Sheet 1

Fig. 1.

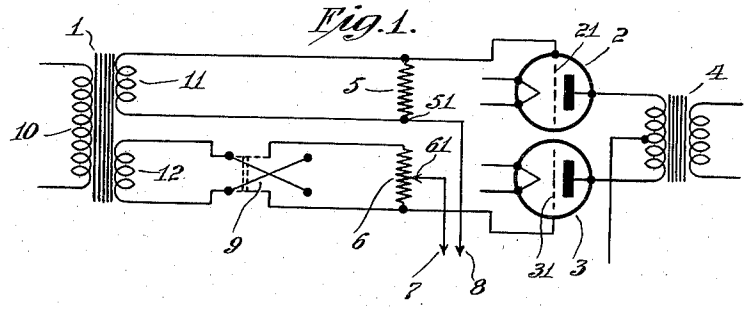


Fig. 2.

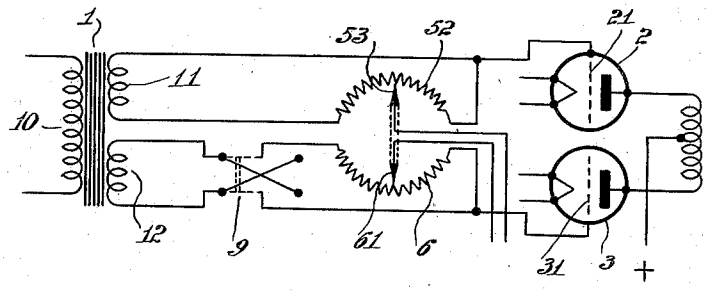
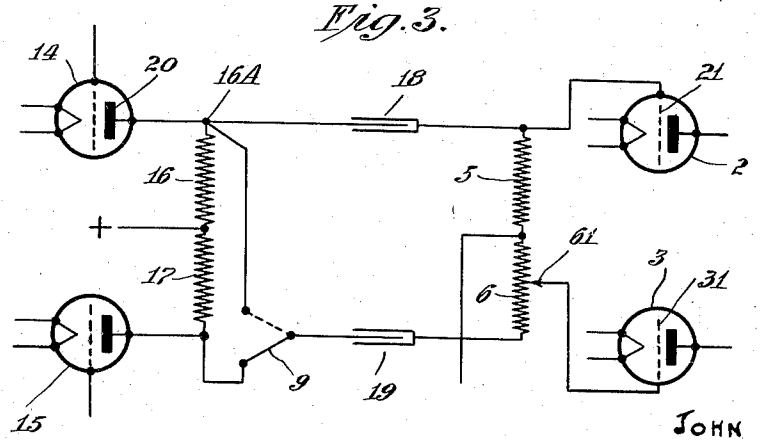


Fig. 3.



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Filed Aug. 6, 1936 2 Sheets-Sheet 2

Fig. 4.

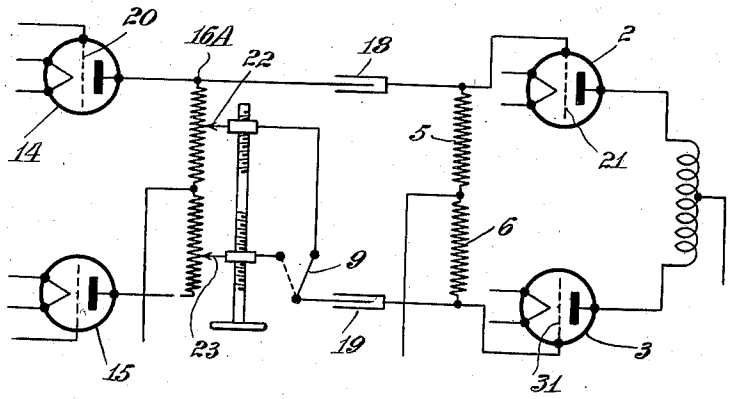


Fig. 5.

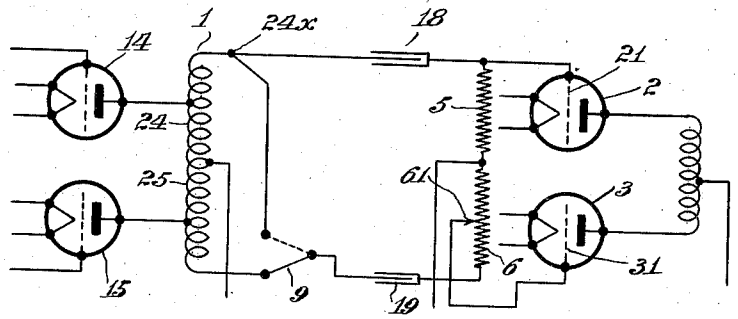
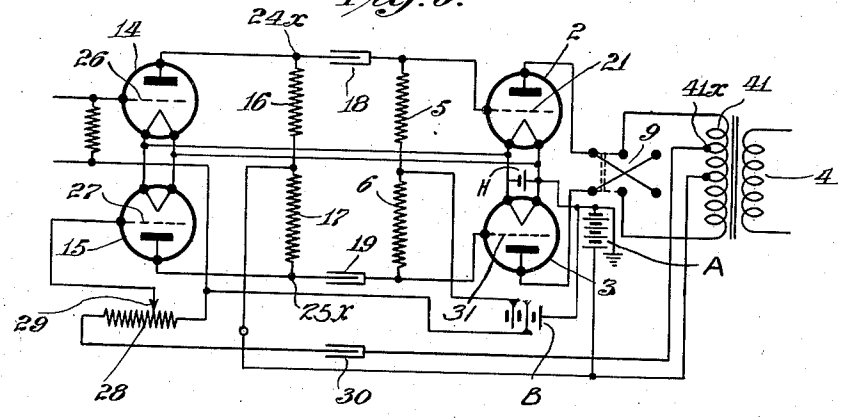


Fig. 6.



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UNITED STATES PATENT OFFICE

2,162,389

PUSH-PULL AND LIKE AMPLIFYING SYSTEMS

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In Great Britain October 7, 1935

3 Claims. (Cl. 179—171)

In devices utilizing push-pull and like amplifying stages; for example, audio-frequency amplifiers and alternating current test instruments, it is well known that for optimum operation such an amplifier stage should be balanced as closely as possible; that is, that the alternating currents arising in the anode circuit of the two thermionic valves comprising one reciprocally acting stage shall be equal and opposed in phase.

With commercial apparatus, owing to differences in the characteristics of various valves, this condition is seldom realized and therefore, in order to adjust such an amplifying stage to a more exact balance, the use of a potential divider or potential dividers connected across one or both sides of the split secondary winding of an input transformer, has been suggested. The object of such an arrangement has been so to adjust the relative inputs to the grid circuits of the two valves that the alternating output currents are equal.

According to my present invention, arrangements are provided by means of which one or both the inputs to the two valves can be adjusted in amplitude, a changeover or reversing switch being disposed in the connections for or to one of the grids, so that the alternating potentials applied to the grid of both valves are in the same phase. In this condition, with exact balance, no alternating current should appear in the anode circuit and the potential adjusting means provided can be adjusted until this condition is attained or very closely approximated.

In all cases, the arrangement may be adjusted until no alternating current is observed in the anode circuit either audibly or otherwise, and the reversing switch is then changed over, when the circuit will operate in its optimum balanced condition. When, owing to slight dissimilarity of the characteristic curve of two valves, the anode alternating current cannot be reduced completely to zero, it can, however, be reduced to a minimum value, and the circuit, when reversal of the switch has been performed, will operate under the best conditions possible with the given pair of slightly dissimilar valves.

The invention can be applied also to cases in which each of the stages of push-pull amplification is coupled or fed by means of impedance, resistance or auto-transformer coupling, operative through coupling condensers in known manner.

In order to carry out the invention when such types of circuit are in use, the input grid leak resistances of a push-pull stage are formed as potentiometer resistances, the valve grids being connected to sliding contacts on the said potentiometers.

Or, in an alternative scheme using a coupling of the last named type, fixed grid leak resistances are used and the split or divided anode chokes, resistances or auto-transformer connected to the two anodes of a previous stage are made with variable, sliding or adjustable tapping contacts, so that an alternating potential of varying ratio can be transferred from said anode impedances or the like, through the coupling condensers to the grid of the valve of a consequent amplifying stage.

With all arrangements of this class a changeover switch is provided by means of which the terminal of the coupling condenser of one arm of such adjustable coupling section can be switched over, during balancing, to a symmetrical point on the anode resistance, inductance or auto-transformer of the opposed arm.

Such switching will, in practice, not substantially alter the value of the alternating potential applied to the grid of the valve being balanced, but reverses its phase during testing and adjustment. On re-reversal, the system functions in its correctly balanced condition.

For the more detailed explanation of the nature of the invention, and as indicating particular methods of carrying it into effect, reference is made to the appended drawings, Figs. 1 to 6 diagrammatically illustrating various embodiments of the invention, Fig. 1 showing a single push-pull amplifying stage with transformer coupling, Fig. 2 the use of two potentiometers to avoid the change-over of the valves, Fig. 3 an arrangement in which the anodes of the valves are connected through impedances with the positive pole of the supply and through condensers with the grids of a second pair of valves, Fig. 4 a circuit in which the grid leaks are connected to the anode impedances through symmetrical variable tapping contacts, Fig. 5 an arrangement in which an auto-transformer is used, and Fig. 6 illustrating diagrammatically the application of the invention to "paraphase" circuits.

Fig. 1 shows diagrammatically a single push-pull amplifying circuit stage having transformer coupling. Herein, an input transformer 1 feeds into two valves 2 and 3, the anodes of which are coupled in known manner to a positive pole of supply through a transformer 4. The input transformer 1 is provided with two secondary windings 11 and 12 and a primary winding 10. Across the secondary 11 a resistance 5 is connect-

ed and across the secondary 12 a potentiometer resistance 6 is arranged. The grid bias connections 7 and 8 are connected, one to a fixed point, for example, the terminal 51 of the resistance 5, whilst the other is connected to the slider or variable tapping element 61 of potentiometer 6. One of each of the terminals of the secondary windings are connected to the control grids 21 and 31 of the valves 2 and 3. Between the potentiometer terminals and the corresponding secondary of the input transformer, a changeover switch 9 is arranged, which enables the phase of the alternating potential applied to the control grid 31, to be reversed for the purpose herein referred to.

If the valve, which is placed in a socket connected to the potentiometer, proves to be the one having the lesser magnification, whereby a perfect balance cannot be attained, the valves are changed over in position and the process of adjustment repeated until balance is produced.

In other arrangements, such changeover of the valves may be avoided by utilizing two potentiometers connected in a circuit as shown diagrammatically in Fig. 2. In this arrangement, the secondary windings 11 and 12 are each bridged by potentiometers 52 and 6 and the variable tapping contacts 53 and 61 may be arranged separately from an electrical point of view, but may be mounted on a common adjustment spindle and may be traversed during adjustment over the potentiometer resistances 52 and 6 in opposite senses. The changeover switch 9 is arranged in connection with one of the transformer secondaries, as in the previous arrangement.

Fig. 3 shows a simple circuit in which the anodes of a pair of valves 14, 15 are connected through impedances 16 and 17 to a suitable positive pole of supply, and, through coupling condensers 18, 19 are linked to grids 21, 31 of the valves 2 and 3. The grid electrodes of these valves are also connected to grid leak resistances 5 and 6, one of which 6 is formed as a potentiometer. The corresponding coupling condenser 19 is connected to the changeover switch 9 by means of which it can, during adjustment, be connected to the common juncture 16A of impedance and anode 20. By this means, the same potential of identical phase is applied to the grid circuit including the coupling condenser 19, and by adjustment of the potentiometer variable contact 61, the valves may be brought to a condition of balance. If necessary, they can be reversed in position for the reasons hereinbefore set forth.

In yet a further modified circuit, indicated schematically in Fig. 4, both the grid leaks may be of fixed value, but they are connected on the anode impedances through the symmetrically variable tapping contacts or sliders 22 and 23 to one or other of which the coupling condenser 19 may be switched. The other coupling condenser may be connected to the termination 16A of the symmetrical arm of the impedance. Similar arrangements may be made utilizing an auto-transformer in each arm of the anode circuit or a common auto-transformer with middle tapping thereon, connected to both anodes.

A circuit of this kind, for example, is indicated diagrammatically in Fig. 5. In this circuital arrangement, the anodes of the valves 14, 15 are connected through the center tapped windings 24, 25 of the common auto-transformer 1 to a suitable positive source of supply. A secondary point $24x$ is connected to a grid 21 through the coupling condenser 18, and a similar and symmetrical secondary point $25x$ is connected through the secondary coupling condenser 19 to the opposed grid 31. Potential adjustment may be made by means of the adjustable potentiometer grid leak 6 in the manner herein set forth, when the changeover switch 9 has been manipulated to bring the termination of the coupling condensers to an equipotential point $24x$. On reversal to the normal position of the switch, the device functions in a balanced condition.

The invention can be applied to circuits of the type in which a unilateral circuit involving one valve only is coupled to and controls a balanced two-valve anode output. Such circuits may be of the type known as "paraphase" circuits and a method of applying the invention to a circuit of this kind is indicated schematically in Fig. 6.

In this figure, an input circuit is connected to one valve only of the pair 14, 15, the grid 26 of one of said valves being alone connected to the input circuit, the anode of valve 14 is coupled to the termination $24x$ of the symmetrically tapped resistance 16, 17, the center point of which is connected to a suitable anode supply. Both extremities of the said anode resistance are connected through the coupling condensers to the grids 21, 31 of a push-pull output system, a center tapped anode transformer being connected to the anodes of said valves. A point $41x$ on the primary of the sand transformer is connected through a resistance 28 and a condenser 30 to the bias potential source influencing grid electrode 27, a sliding contact 29 on this resistance being connected directly to grid 27. Between the anodes of the valves 2 and 3 and the output transformer primary 41 a changeover switch 9 is interposed. When balancing is in progress, the switch is reversed as in the previous arrangements, and the sliding or adjustable contact 29 on the resistance 28 is adjusted until no current or a minimum current is produced in the anode circuit when the switch can again be reversed and the whole system acts in a condition of optimum balance.

It will be seen that grid 26 is connected to a point on the bias battery B to which also grid 27 connects via the potentiometer 29. The two grids 21 and 31 connect to a similar point on the bias battery.

The cathodes of the valves 14, 15, 2 and 3 can be heated by means of current drawn from battery H, and the anodes of said valves are connected to and fed by the battery A.

What I claim is:

1. In a push-pull type of amplifying stage, reciprocally active valves having alternating current input circuits and grid electrodes, means for adjusting the relative alternating potential amplitudes applied to the input circuits of the two valves, and means to influence and reverse the phase of the alternating potential applied to the input of one of said valves in the course of relative alternative grid potential adjustment to effect optimum balance of the amplifying stage.

2. In a push-pull type of amplifying stage, two reciprocally active valves having input circuits and grid electrodes, an input transformer having a balanced secondary winding for each input circuit, a fixed resistance bridged across one of said secondary windings and an equal potentiometer resistance across the other winding, and a changeover switch between one of said secondary windings and the resistance bridged across it, whereby the phase of the alternating potential applied to one grid may be reversed.

3. In an amplifying system, an amplifying stage comprising a split anode impedance, a push-pull amplifying stage comprising two valves each having an input control grid and a grid circuit resistance, condensers for coupling said impedance with said grids, a common terminal for said condensers, one of the condensers being normally disconnected therefrom, an adjustable tapping contact in the grid circuit of one valve for varying the amount of grid resistance in circuit, a switch for transferring the coupling through said one condenser to said common terminal, whereby the same phase of alternating potential may be applied to the grids of the two valves.

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