

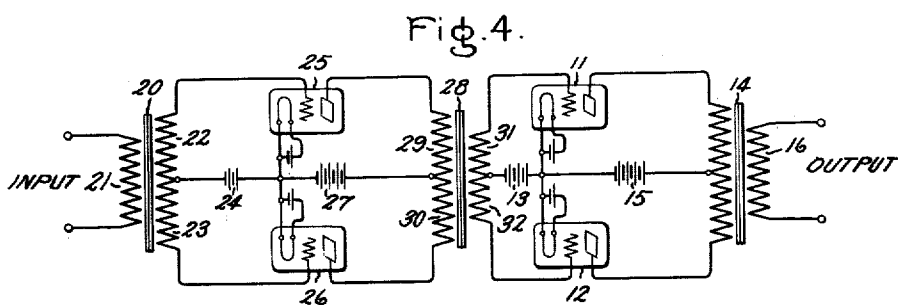
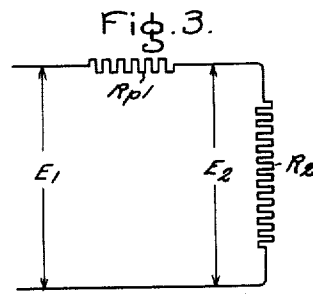
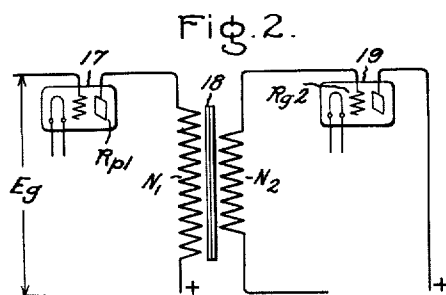
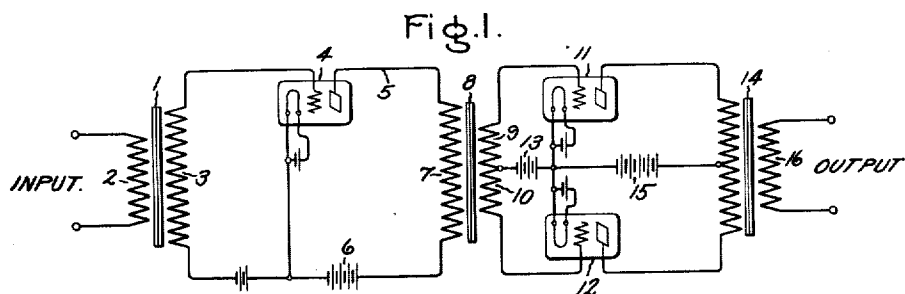
Dec. 13, 1932.

J. O. BAKER

1,890,489

AMPLIFYING SYSTEM

Filed Oct. 20, 1931



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UNITED STATES PATENT OFFICE

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AMPLIFYING SYSTEM

Application filed October 20, 1931. Serial No. 570,000.

My invention relates to means for amplifying alternating currents and more particularly to amplifier means of that character embodying electron discharge devices as amplifiers for the delivery of relatively large amounts of power. A well known form of an amplifier means to which my invention relates is an audio frequency amplifier employing a driver or voltage amplifier stage and an output or power stage connected in cascade, each stage employing one or more suitable electron discharge devices which may be of the vacuum tube type.

My invention has for one of its objects to provide means whereby an amplifier means of the above type employing electron discharge devices of a certain rated capacity may be caused to produce in the output circuit far greater amounts of alternating power than has heretofore been practicable.

Another object of my invention is to provide an electron discharge amplifier having a coupling unit between the driver stage and the output stage which may provide good regulation of the alternating current potentials derived from the driver stage and applied to the input circuit of the output stage for a wide range of input potentials involving the positive grid bias range of operation of the electron discharge device or devices employed in the output or power stage.

A further object of my invention is to provide an electron discharge amplifier having a coupling means between the voltage amplifier or driver stage and the power or output stage which provides a reflected impedance substantially less than the grid impedance of the power output electron discharge device when the grid or input electrode of the latter is in a positive range of potentials, thereby providing a condition for improved regulation.

Heretofore it has been found that a considerable increase in the power output of circuits of this type may be obtained by

negatively biasing the grid of the electron discharge device to such a value that substantially no anode current flows during no load conditions, and by allowing the grids of said discharge devices to become positive during operation. In such circuits a portion of the load or anode circuit impedance is composed of the grid impedance of the following electron device reflected through the coupling unit. This load impedance changes greatly due to the change in grid impedance as the grid potentials change from the negative to positive range, thus ordinarily limiting the power output or necessitating the use of electron discharge devices of greater capacity, or a plurality of discharge devices connected in multiple to carry the peak power output.

In accordance with my invention, I have found that by providing a transformer coupling unit having a regulating effect upon the impedance changes, I am able to increase still further the distortionless power output of electron discharge devices employed in the power or output stage without resorting to devices of higher output rating.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof, will be better understood by reference to the following description taken in connection with the accompanying drawing in which Fig. 1 represents an amplifier employing a preferred embodiment of my invention; Fig. 2 represents an application of my invention to a simple cascade amplifier; Fig. 3 represents diagrammatically the electrical equivalent of the circuit shown in Fig. 2; and Fig. 4 is a modification of an amplifier embodying my invention.

Referring to Fig. 1 of the drawing, I have illustrated therein a step up transformer 1

arranged with a primary winding 2 serving as an input to the system and adapted to be energized by an alternating current wave of varying potential, and a secondary winding 3 connected to the input electrode of an electron discharge device 4, to apply the potential of the alternating current wave thereto. The output or anode circuit 5 of the amplifier electron discharge device 4 includes a suitable source of potential 6 and the primary winding 7 of a coupling unit or transformer 8. The input wave potentials amplified by device 4 are transmitted through the output circuit 5 and the coupling unit 8 to the control electrodes of two electron discharge devices 11 and 12 arranged in balanced or push pull relation in connection with the opposite extremities of the secondary winding of the transformer 8. An intermediate terminal of this secondary winding is connected through a suitable negative biasing source of potential 13 to the cathodes of both devices. The transformer thus provides a coupling unit between the output circuit of the driver stage and the input circuit of the balanced amplifier or output stage. The anodes of the devices 11 and 12 are connected to opposite extremities of the primary winding of the output transformer 14, an intermediate point of which is connected with a suitable source of anode potential 15. The secondary winding 16 of the output transformer 14 is adapted to be connected to an output device or other source of load (not shown).

In practicing my invention I adjust the negative potential source 13 to such a value that the grids of devices 11 and 12 are maintained sufficiently negative with respect to the cathodes substantially to preclude the flow of anode current at no load conditions. In an amplifier thus arranged, the positive half cycles of the input device are amplified by one of the electron discharge devices 11 and 12 and the negative half cycles are amplified by the other of said electron discharge devices, these waves being combined to produce an undistorted and amplified wave in the secondary winding 16 of the output transformer 14 of substantially the same form as that supplied to the input winding 2.

In operation, the grids of the discharge devices 11 and 12 are allowed to become positive, thereby increasing the allowable impressed alternating current amplitude. It has been found that a maximum of energy can be obtained in the output circuit of the discharge devices with a minimum of distortion of the impressed alternating current wave by providing the coupling transformer 8 with secondary windings 9 and 10 of such ratio to the primary winding 7 and having impedances such that the load reflected in the plate circuit of the preceding electron discharge device changes but a small per cent when the grid potentials of the output dis-

charge devices change from the negative into the positive range during each half cycle.

For an explanation of the design and the operation of the coupling transformer 8, reference may be had to Fig. 2 in which a portion of a simple cascade amplifier is shown, and to Fig. 3 which represents the electrical equivalent of the circuit in Fig. 2. Electron discharge device 17 is coupled to electron discharge device 19 by a transformer 18 having N_1 turns on the primary and N_2 turns on the secondary. The internal anode circuit impedance of electron discharge device 17 is represented in Fig. 3 as an impedance R_{p1} while the grid impedance R_{g2} of device 19 is represented as R_2 transferred through the coupling device 18 to the anode circuit of device 17. When the grid of device 19 is at a negative potential the transferred grid impedance R_2 of device 19 is substantially infinite, and the input alternating current voltage E_1 across this impedance R_2 is substantially equivalent to the input voltage E_1 . When the grid of device 19 is at a positive potential, the transferred grid impedance R_2 of device 19 has a finite value and the voltage E_2 across the impedance R_2 may be expressed as:

$$E_2 = \frac{R_2}{R_{p1} + R_2} E_1$$

If we assume a certain desired per cent of regulation of the voltage E_2 for a range between negative and positive grid potentials as being "A", then for a positive potential on the grid the voltage

$$E_2 = \frac{R_2}{R_{p1} + R_2} E_1 = AE_1$$

or

$$\frac{R_2}{R_{p1} + R_2} = A$$

From this equation we derive the following relation:

$$R_2 = \frac{A}{1-A} R_{p1}$$

For the value of R_2 we may substitute its equivalent

$$\left(\frac{N_1}{N_2}\right)^2 R_{g2}$$

Hence

$$\frac{N_1}{N_2} = \sqrt{\frac{A}{1-A}} \sqrt{\frac{R_{p1}}{R_{g2}}}$$

For any particular values of grid bias potential and anode potential of an electron discharge device circuit, the anode impedance R_{p1} and the grid impedance R_{g2} is known. Then for any assumed value of the per cent of regulation A, the turn ratio of the transformer is readily calculated from the above equation. In applying the formula to a transformer coupling a number of electron

discharge devices together as in Figs. 1 and 4, the impedance values of only one voltage amplifier device and one power output device are used and thus the ratio between each primary and secondary is obtained. Thus in Fig. 1 the ratio of the winding 7 to winding 9 must be equal to that found by means of the above equation.

In practice it will be found that the ratio will usually be greater than unity, that is, the transformer will usually have a step down ratio when used with the tubes on the market at the present time. The secondary winding should not have an excessive direct current resistance, otherwise a change in grid potential will also result in distortion. In any case, the impedance of the secondary winding is substantially less than the grid impedance of the output tube when the grid is at a positive potential.

In Fig. 4, I have illustrated another application of my invention wherein a push pull or balanced amplifier stage is utilized to drive a push pull or balanced output stage such as is shown in Fig. 1. Similarly as in the other figures, the ratio of the primary winding 29 to the secondary winding 31 must be equal to the ratio obtained by the equation.

My invention therefore has the advantages:

1. That the grids of the electron discharge devices may be driven to a greater positive potential during operation without introducing distortion than has heretofore been practicable.

2. That the interstage coupling device provides an impedance balance between the driver and driven stages such that the reflected impedance of the driver stage on the input circuit of the output stage is substantially less than the grid impedance of each of the output devices when the grids are at a positive potential.

3. That the load impedance reflected back into the anode circuit of the electron discharge device is substantially greater than the anode impedance.

4. And that the distortionless output may be several times greater than that obtainable heretofore, because of the increased permissible grid swing without distortion.

While I have shown and described my invention in connection with certain specific embodiments it will, of course, be understood that I do not wish to be limited thereto, since it is apparent that the principles herein disclosed are susceptible of numerous other applications, and modifications may be made in the circuit arrangements and in the instrumentalities employed without departing from the spirit and scope of my invention as set forth in the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. A coupling device adapted to connect a

driver and a driven stage of an amplifier, said driven stage comprising a discharge device having a grid, said coupling device being provided with primary and secondary windings, said secondary winding having an impedance lower than the input impedance of the driven stage when the grid of the said driven stage becomes positive during operation.

2. A coupling transformer adapted to connect a voltage amplifier vacuum tube to a power output vacuum tube, said transformer having a low resistance secondary winding whose impedance is less than the input impedance of said power output tube when the grid of said power output tube is driven into the positive range of grid potentials by the peak of the wave to be amplified.

3. In an electron tube circuit, a power output electron tube, an electron tube driver for said power output tube, an impedance adjusting transformer connected to couple said driver tube to said output tube, said transformer having an impedance ratio whereby the load impedance reflected back into the anode circuit of said driver tube is substantially greater than the anode impedance of the driver tube.

4. In an electrical system adapted to transmit alternating current energy, an electron discharge device adapted to transmit alternating current energy, a second electron discharge device, a grid, a cathode and an anode for each of said devices, a transformer connected between said devices, said transformer having a secondary impedance substantially less than the impedance of the grid circuit of said second device under the condition that the grid of the second device is at a positive potential.

5. In an electrical system adapted to transmit alternating current energy, an electron discharge device arranged to transmit alternating current energy, a second electron discharge device, a grid, a cathode and an anode for each of said devices, a stepdown transformer connected between said devices, said transformer having a secondary impedance substantially less than the impedance of the grid circuit of said second device when the grid of said second device is made positive with respect to the cathode by the magnitude of the transmitted alternating current energy.

6. In an electrical circuit adapted to transmit and reproduce alternating current waves, an electron discharge device for amplifying the potential of said alternating current waves, a pair of power output electron discharge devices, each of said electron discharge devices having an anode, a cathode and a grid, transformer means interposed between said amplifying discharge device and connecting said power output devices in push pull relation, a source of direct current

potential connected to bias negatively the grids of said power output electron devices during amplification sufficiently to preclude substantially the flow of no load anode current, said transformer means having a secondary impedance substantially less than the impedances of the grids in said output devices when the grids are at a positive potential.

10 In witness whereof, I have hereunto set my hand.

JUDD O. BAKER.

DISCLAIMER

1,890,489.—*Judd O. Baker*, Hastings-on-Hudson, N. Y. AMPLIFYING SYSTEM. Patent dated December 13, 1932. Disclaimer filed October 15, 1935, by the assignee, *General Electric Company*.

Hereby enters the following disclaimer to claims 1, 2, 3, and 4 of said Letters Patent which are in the following words, to wit:

"1. A coupling device adapted to connect a driver and a driven stage of an amplifier, said driven stage comprising a discharge device having a grid, said coupling device being provided with primary and secondary windings, said secondary winding having an impedance lower than the input impedance of the driven stage when the grid of the said driven stage becomes positive during operation.

"2. A coupling transformer adapted to connect a voltage amplifier vacuum tube to a power output vacuum tube, said transformer having a low resistance secondary winding whose impedance is less than the input impedance of said power output tube when the grid of said power output tube is driven into the positive range of grid potentials by the peak of the wave to be amplified.

"3. In an electron tube circuit, a power output electron tube, an electron tube driver for said power output tube, an impedance adjusting transformer connected to couple said driver tube to said output tube, said transformer having an impedance ratio whereby the load impedance reflected back into the anode circuit of said driver tube is substantially greater than the anode impedance of the driver tube.

"4. In an electrical system adapted to transmit alternating current energy, an electron discharge device adapted to transmit alternating current energy, a second electron discharge device, a grid, a cathode and an anode for each of said devices, a transformer connected between said devices, said transformer having a secondary impedance substantially less than the impedance of the grid circuit of said second device under the condition that the grid of the second device is at a positive potential."

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"2. A coupling transformer adapted to connect a voltage amplifier vacuum tube to a power output vacuum tube, said transformer having a low resistance secondary winding whose impedance is less than the input impedance of said power output tube when the grid of said power output tube is driven into the positive range of grid potentials by the peak of the wave to be amplified.

"3. In an electron tube circuit, a power output electron tube, an electron tube driver for said power output tube, an impedance adjusting transformer connected to couple said driver tube to said output tube, said transformer having an impedance ratio whereby the load impedance reflected back into the anode circuit of said driver tube is substantially greater than the anode impedance of the driver tube.

"4. In an electrical system adapted to transmit alternating current energy, an electron discharge device adapted to transmit alternating current energy, a second electron discharge device, a grid, a cathode and an anode for each of said devices, a transformer connected between said devices, said transformer having a secondary impedance substantially less than the impedance of the grid circuit of said second device under the condition that the grid of the second device is at a positive potential."

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