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D. K. GANNETT

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ALTERNATING CURRENT AMPLIFIER

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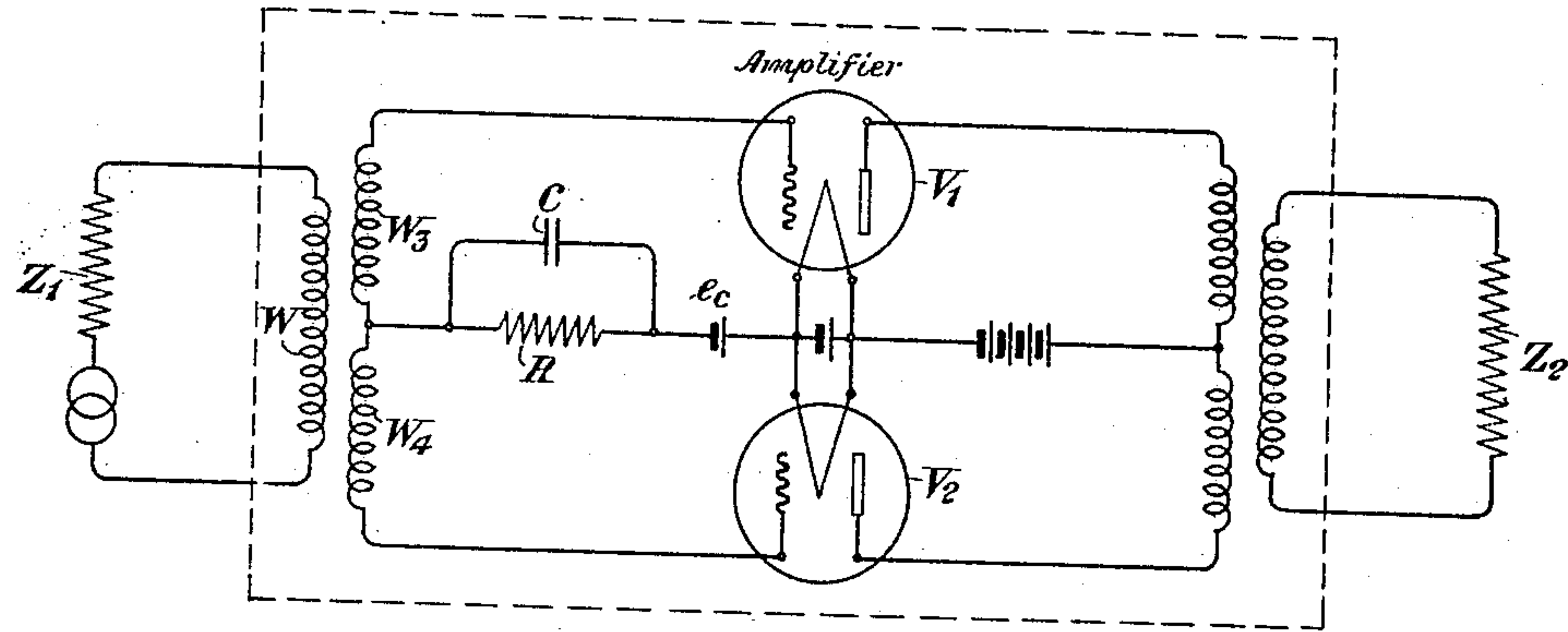


Fig. 1

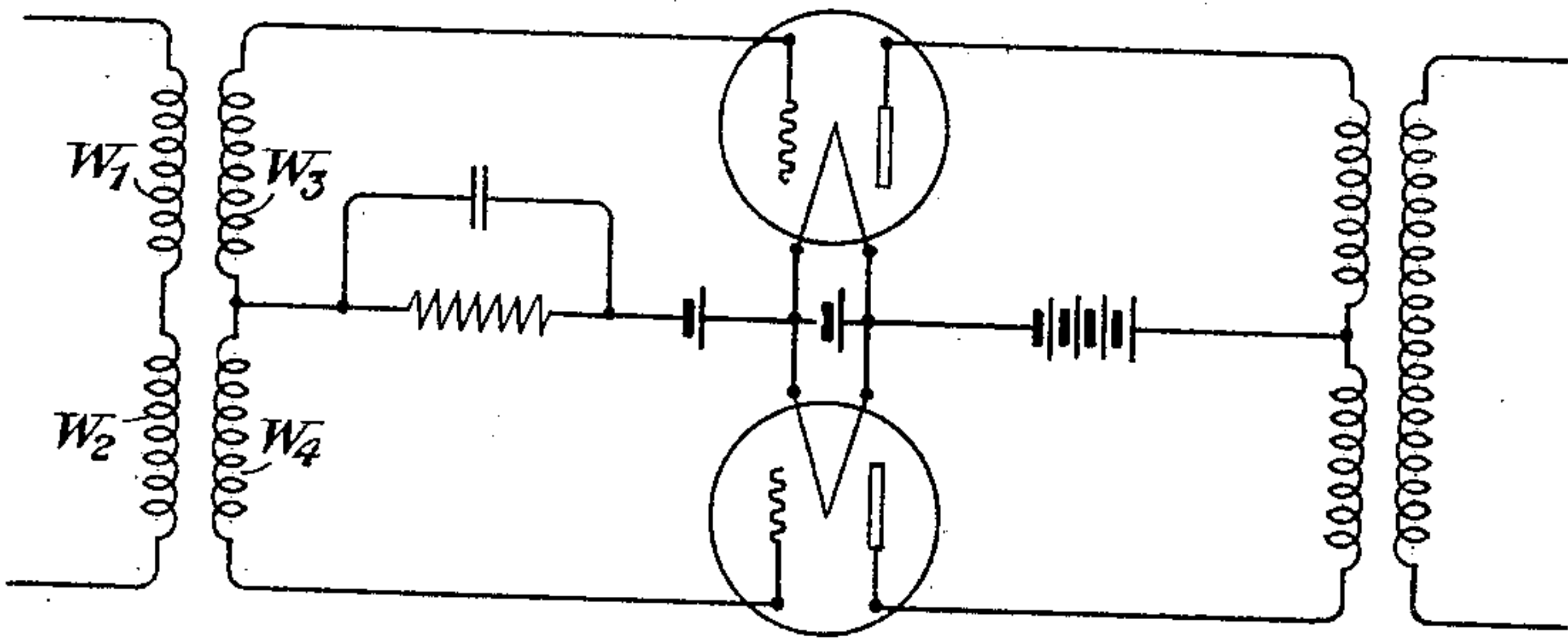


Fig. 2

INVENTOR.
D. K. Gannett
BY *g e y o r*
ATTORNEY

UNITED STATES PATENT OFFICE

DANFORTH K. GANNETT, OF JACKSON HEIGHTS, NEW YORK, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK

ALTERNATING CURRENT AMPLIFIER

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This invention relates to means for amplifying alternating currents and, more particularly, to vacuum tube amplifiers.

The object of the invention is to provide an amplifier of alternating currents which will tend to give a constant volume output.

In accomplishing the above stated object I employ two three-electrode vacuum tubes connected in push-pull relation and provide for the automatic adjustment of the output impedance of the tubes so that for low volume in the input of the amplifier the tube output impedance is low and for high volume in the input of the amplifier the tube output impedance is high, as will be more fully explained below.

One advantage of the amplifier of my invention is that it may be used not only for single frequencies, but also to amplify voice currents, the distortion in the latter case being insufficient to threaten the intelligibility of the output.

Another advantage of my amplifier is that it may be adjusted to give either (1) a gain which varies inversely with the input volume or (2) a constant gain for a certain range of low volumes and a reduced gain for volumes above the value chosen.

The invention will be more clearly understood when the following detailed description is read with reference to the accompanying drawing.

Figure 1 of the drawing shows diagrammatically one arrangement of the tubes and connecting circuits of my amplifier, while Fig. 2 shows a second arrangement in which the input connection is modified.

With reference first to Fig. 1 of the drawing, two three-electrode vacuum tubes V_1 and V_2 are connected in push-pull relation, as shown, and the input circuit at the left is inductively connected through its winding W to the grid-filament circuits of the tubes, the secondary transformer windings W_3 and W_4 being formed about a common core. A resistance R and a condenser C are connected in parallel in the common grid circuit of the tubes V_1 and V_2 . A source of direct current voltage e_c is also included in the common grid circuit. In the arrangement shown in Fig. 1

the impedances indicated by Z_1 and Z_2 , which are the connecting impedances, as seen through the input and output transformers of the amplifier, should be low in comparison with the vacuum tube impedance.

If it is desired that the amplifier give a gain which varies inversely with the input volume, the direct current voltage e_c should be approximately zero, or possibly slightly positive, but in no case appreciably more negative than zero. Accordingly, for weak signals, that is, for low volume in the input, the effective direct current potential on the grids of the tubes is represented by e_c , and since this voltage has a value which is not substantially more negative than zero, the output impedance of the tubes will be low. If, however, the input volume increases, the grids of the tubes are made appreciably positive during the positive peaks of the input wave, and a grid-filament current flows. This current results in the charging of the condenser and places a potential across the resistance R which renders the effective direct current grid potential considerably more negative.

The effect of making the direct current grid potential more negative is to increase the output impedance of the tubes. A well-known equation for a vacuum tube is:

$$i_B = k(E_B + \mu E_c)^p$$

where

i_B = plate to filament current

E_B = d. c. plate to filament potential

E_c = d. c. grid to filament potential

μ = amplification factor of tube, and p and k = constants.

From this equation the expression for the output impedance, R_o , is easily derived:

$$R_o = \frac{dE_B}{di_B} = \frac{1}{k(E_B + \mu E_c)^{p-1}}$$

In practice, the exponent p lies between 1.5 and 2.0 so that the exponent $p-1$ in the denominator of the expression for R_o lies between 0.5 and 1.0. It is evident that as E_c is altered from zero to a negative value, the value of R_o increases.

The amplification of the circuit of Fig. 1

is shown by its transfer admittance which is equal to:

$$\frac{a\mu}{2b^2R_o + Z_2}$$

where a = turns ratio of $W_3 + W_4$ to W_1 , and $2b^2R_o$ = output impedance of tubes V_1 and V_2 as seen through the output transformer from the terminals of Z_2 .

If Z_2 is small compared with $2b^2R_o$, the transfer admittance approaches being inversely proportional to R_o . Therefore, the increased tube output impedance which has been shown to follow from the application of larger input volume, results in decreased amplification.

The relation of the values of the resistance R and the capacity C should be such that the time constant is suitable to the purpose for which the amplifier is being used. If voice currents are to be amplified, the time constant must be high enough to prevent pronounced distortion due to fluctuation of the gain with the instantaneous volume changes of the voice current. On the other hand, the time constant should not be so great that, when the average volume changes, the readjustment will be so sluggish that syllables or words are transmitted before the readjustment becomes effective. A time constant of approximately .005 second will probably be found satisfactory in most cases of amplification of voice currents, but in each case the most suitable value should be determined by experiment.

If it is desired that the amplifier give a constant gain over a range of low volumes and, beyond the upper limit of that range, a gain which varies inversely with the volume, the direct current grid voltage e_c should be made sufficiently negative to prevent the grids from being made appreciably positive until the volume limit is reached at which it is desired to have the gain begin to vary.

The amplifying device described above, and shown in Fig. 1, will amplify voice currents without appreciable distortion (1) because the tubes V_1 and V_2 are connected in push-pull relation, the second and other even harmonics thus being balanced out, and (2) because the impedance connected to the grids of the tubes V_1 and V_2 (Z_1) is sufficiently low to keep the instantaneous variations in the grid-filament impedance from affecting the wave shape.

The feature of a low connecting impedance, as discussed above, is not necessarily required in the grid circuit. This requirement is avoided if the mutual impedance between the two coils in the grid circuit is eliminated so that the input impedance of the amplifier is determined by the grid-to-grid impedance, always high, and not by the two grid-to-filament impedances in parallel. Such elimination is accomplished if the arrangement

shown in Fig. 2 of the drawing is employed. In this case, the windings W_1 and W_3 form one transformer, and the windings W_2 and W_4 a second separate transformer. The low windings W_1 and W_2 are connected in series, as are the high windings W_3 and W_4 .

While the invention has been described in one specific embodiment thereof (and a modification of that embodiment) for the purpose of illustration, it is to be understood that it is capable of embodiment in other and different forms within the scope of the invention as defined by the appended claims.

What is claimed is:

1. An amplifier of alternating currents including two vacuum tubes each having a cathode, an anode and a control electrode or grid, connected in push-pull relation, an input circuit therefor, an output circuit connected thereto, a single path for supplying alternating current to said input circuit, means included directly in said input circuit for maintaining a direct current potential on the grids of the vacuum tubes such that the output impedance of the vacuum tubes will have a relatively low value when the volume in said input circuit is low, and a grid leak arrangement in the common branch of the grid circuits for increasing the output impedance of the vacuum tubes in response to an increase of volume in said input circuit, the impedance of said connected output circuit being low in comparison with the output impedance of the vacuum tubes.

2. In an amplifier of alternating currents including two vacuum tubes each having a cathode, an anode and a control electrode or grid, connected in push-pull relation, an input circuit therefor, an output circuit connected thereto, a single path for supplying alternating current to said input circuit, and a grid leak arrangement in the common branch of the grid circuits, the method of producing an output which tends to be constant consisting in adjusting the relation between the impedance of said connected output circuit and the output impedance of the vacuum tubes so that the former is low in comparison with the latter, setting the output impedance of the vacuum tubes at a relatively low value for low input volume, and causing an increase of input volume to act directly through the grid leak arrangement to effect an increase of the output impedance of the vacuum tubes.

3. An amplifier of alternating currents including two vacuum tubes each having a cathode, an anode and a control electrode or grid, connected in push-pull relation, an input circuit therefor, an output circuit connected thereto, a single path for supplying alternating current to said input circuit, and means controlling the output impedance of said vacuum tubes so that it is relatively low for low input volume and relatively high for

high input volume, the impedance of said connected output circuit being low in comparison with the output impedance of the vacuum tubes.

5 4. In an amplifier of alternating currents including two vacuum tubes each having a cathode, an anode and a control electrode or grid, connected in push-pull relation, an input circuit therefor, an output circuit connected thereto, a single path for supplying
10 alternating current to said input circuit, and a grid leak arrangement in the common branch of the grid circuits, the method of producing an output which tends to be constant consisting in adjusting the relation between the impedance of said connected output circuit and the output impedance of the vacuum tubes so that the former is low in
15 comparison with the latter, adjusting the value of the voltage on the grids of the vacuum tubes so that the output impedance of the tubes will be relatively low when the input volume is low, and causing an increase of input volume to act directly through the
20 grid leak arrangement to render the output impedance of the tubes relatively high.

In testimony whereof, I have signed my name to this specification this 1st day of October, 1927.

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