

July 3, 1945.

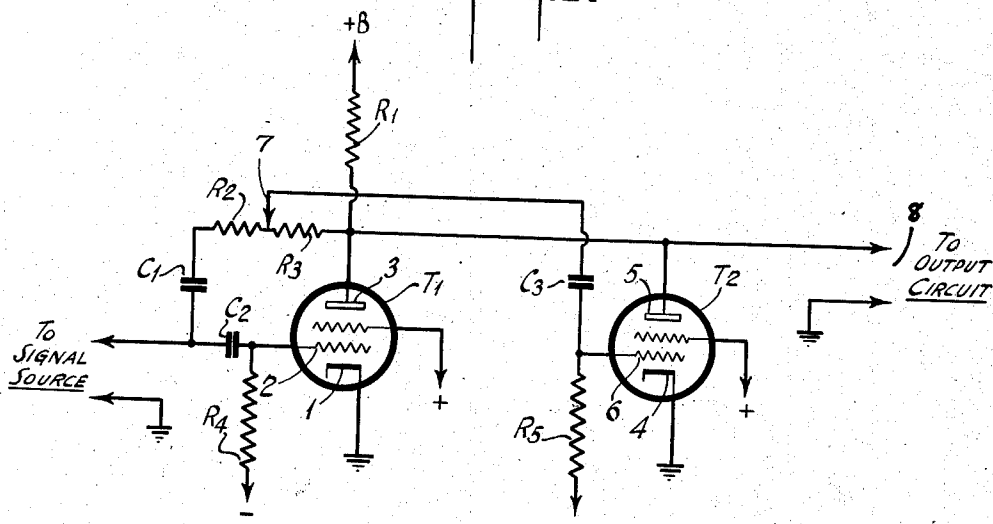
J. R. FORD

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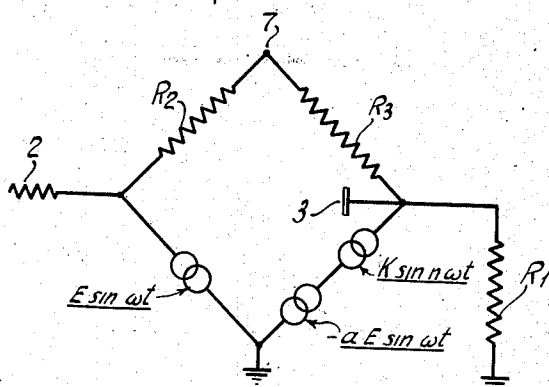
AMPLIFIER CIRCUIT

Filed Oct. 13, 1943

Fig. 1.



F19.2.



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2,379,699

AMPLIFIER CIRCUIT

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Application October 13, 1943, Serial No. 506,075

5 Claims. (Cl. 179—171)

My present invention relates generally to amplifier circuits, and more particularly to a novel method of, and means for, reducing distortion in an amplifier stage without reducing its gain.

In the past, various types of inverse feedback arrangements have been used in amplifier circuits. The use of inverse feedback, or degeneration, is indicated wherever it is desired that an amplifier have an output which is relatively free of distortion. There are various reasons why it may not be possible to have an amplifier circuit whose output is substantially free of distortion. For example, the amplifier may have its grid bias supplied by an automatic gain control system, in which case the amplifier may not be operating along the linear portion of its plate current-grid voltage characteristic. Again, the output voltage desired may be excessive, and substantial harmonics may be produced. The load of the amplifier, as for example where the load is a diode, may be non-linear. Prior inverse feedback circuits could substantially reduce distortion arising from such cases. However, the gain of the amplifier stage was concurrently greatly reduced.

One of the main objects of my present invention is to provide a method of substantially eliminating harmonic distortion in an amplifier circuit without appreciable loss of its normal gain.

Another important object of my invention is to provide a signal amplifier which is provided with an electron discharge device adapted to function as a distortion-reducing device without substantial effect on the gain of the signal amplifier.

A further object of my invention is to provide in combination with a signal amplifier whose output and input circuits are coupled by a resistive path, an auxiliary electron discharge device whose input electrode is connected to a point in the resistive path which is at substantially zero signal potential but which is at an appreciable potential with respect to harmonic distortion voltage, the output electrode of the auxiliary device being connected in parallel with the output electrode of the signal amplifier, and amplified signal voltage being derived from a circuit including the parallel output electrodes.

Another object of my invention is to provide a method of substantially reducing harmonic distortion in a signal amplifier which comprises applying the signals to be amplified to the input electrode of an amplifier, developing amplified signal voltage in the output circuit of the amplifier, deriving from the amplifier solely distortion voltage, and utilizing the derived distortion volt-

age substantially to reduce distortion voltage components existing in the output circuit of the signal amplifier thereby maintaining the gain of the signal amplifier at its substantially normal value.

Still other objects of my invention are to improve generally the functioning and efficiency of signal amplifiers of the audio frequency type, and more specifically to provide an audio frequency amplifier circuit which is not only reliable in operation, but is economically manufactured and assembled.

In the drawing:

Fig. 1 is a circuit diagram of an embodiment of my invention,

Fig. 2 is a simplified analysis of the operation of the circuit.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims; the invention itself, however, as to both its organization and method of operation will best be understood by reference to the following description, taken in connection with the drawing, in which I have indicated diagrammatically a circuit organization whereby my invention may be carried into effect.

Referring, now, to the circuit shown in the accompanying drawing let it be assumed that T_1 denotes a conventional amplifier tube of any desired type. While the tube is represented as of the screen grid type, it is to be clearly understood that any of the well known triode or pentode types may be used in place thereof. The signal source is schematically represented, and may be in any desired frequency range. While for purposes of specific illustration it is assumed that the signal source is a source of audio frequency signals, it is to be clearly understood that the signal source may provide signals in a super-audible frequency range. The present invention moreover may be applied to the intermediate frequency and radio frequency ranges, if desired.

The cathode 1 of tube T_1 is shown as being at ground potential, while the signal input electrode 2 is coupled to the high alternating potential side of the signal source through a direct current blocking condenser C_2 . The resistor R_4 connects the signal grid 2 to a direct current potential point which is negative with respect to ground. In other words, the resistor R_4 provides the grid bias path for grid 2. The plate or output electrode 3, is connected to the +B terminal of the energizing direct current source through the load resistor R_1 . Those skilled in the art of radio communication are fully acquainted with the manner

of energizing amplifier circuits from direct current sources, or from the power supply circuit of a radio receiver. This invention is not limited in any way to the particular source of direct current voltages employed to energize the various tube electrodes.

There is provided between plate 3 and grid 2 a path which consists of a voltage divider R_2-R_3 in series with the coupling condenser C_1 . The right end of R_3 is connected directly to the output electrode 3, while the left terminal of condenser C_1 is connected to the high alternating potential side of the signal source. In accordance with my invention, R_2+R_3 is made sufficiently large so that no appreciable negative feedback occurs between the grid and plate of T_1 by virtue of their presence. A point can be found on the divider R_2-R_3 which is at substantially zero signal potential with respect to ground, but which is at an appreciable potential with respect to harmonic distortion component. This harmonic distortion component voltage is applied to an auxiliary electron discharge device for the purpose of substantially eliminating any residual harmonic distortion which may exist across the load resistor R_1 .

This elimination of distortion component existing in the output circuit of amplifier T_1 is secured by employing the tube T_2 . This tube may be of any well known type, such as a triode, screen grid or pentode. Its constants need have no relation to the constants of the device T_1 . Indeed, the electron discharge device T_2 may be, for example, a section of a tube having another electron section performing some useful function with regard to signal transmission. For example, the device T_2 may be one of the electron sections of a twin triode tube, and the other section may act as an amplifier section for the signal output voltage taken off from T_1 . However, my invention is not restricted in any way to such a multiple function for T_2 . The tube T_2 functions as a compensation device.

The cathode 4 of T_2 is established at ground potential, while its plate 5 is connected directly to the plate 3 of tube T_1 . Accordingly, it will be seen that the output electrodes 3 and 5 are connected in parallel so far as the output circuit of T_1 is concerned. The control grid 6 is connected to the aforementioned zero signal potential point on divider R_2-R_3 by means of a direct current blocking condenser C_3 . The grid 6 is connected to a source of negative bias through resistor R_5 . The condenser C_3 is shown connected to the predetermined point on divider R_2-R_3 by means of an adjustable tap 7. It is to be understood that this adjustable tap can be fixed in position once the proper zero signal potential point is found. The output circuit leads are indicated by the numeral 8, and these leads are connected between ground and the paralleled output electrodes 3 and 5. The leads 8 take off from the plate load R_1 amplified signal voltage which is substantially free of harmonic distortion components.

The divider R_2-R_3 may be constructed as a single resistor with a tap thereon adjustable to a point on the divider such that the two portions of the divider have desired magnitudes. The latter should be such that at the junction point a signal balance with respect to ground is obtained leaving only the distortion. On the other hand, the divider may consist of separate resistances R_2 and R_3 whose relative magnitudes are so chosen that at the junction point 7 the signal voltages from the output electrode 3 and

the grid 2 are exactly opposite in phase. However, at the junction point it is important that the ratio of distortion to signal be large.

This distortion voltage is applied to the control grid 6 of electron discharge device T_2 . The plate 5 of the latter will then draw current in such a manner as to oppose the distortion leaving the fundamental signal voltage unchanged. Accordingly, there will be substantially no loss in gain of the amplifier T_1 . It is desirable to have the magnitudes of resistors R_4 , R_5 , R_2 and R_3 large compared to the magnitude of the plate load resistor R_1 and the impedance of the signal input source.

In order to explain more clearly the functioning of my invention the following analysis is presented. Fig. 2 shows a simplified redrawing of elements $R_2-R_3-R_1$ and the grid 2 and plate 3 of tube T_1 . Let it be assumed that tube T_2 has been removed from its socket. An alternating voltage $E \sin \omega t$ is applied between grid 2 and ground. Assume, furthermore, that the amplification of tube T_1 in connection with load resistor R_1 is a , and that R_2+R_3 is sufficiently large so that no appreciable negative feedback occurs between grid 2 and plate 3 by virtue of their presence. The voltage $E \sin \omega t$ represents the signal voltage applied to grid 2 of tube T_1 . The voltages $-aE \sin \omega t$ and $K \sin n\omega t$ represent respectively the amplified plate signal voltage and the distortion voltage generated in T_1 . If

$$R_3=aR_2$$

since generators $E \sin \omega t$ are of the same frequency and opposite phase they form with resistors R_2 and R_3 a balanced bridge such that at point 7 no voltage at this frequency exists.

However, the generator $K \sin n\omega t$ has no compensating generator of the same frequency in the arm of the bridge between grid 2 and ground. Hence, at point 7 we have

$$\left(\frac{1}{1+a}\right)K \text{ volts}$$

of distortion frequencies. If, now, tube T_2 is reinserted in its socket, but its grid 6 disconnected, the effect will be as if R_1 and the B supply were reduced slightly. Connecting grid 6 to point 7 can have no effect insofar as the signal frequency is concerned for no such voltage exists at point 7. However, distortion voltages do exist at point 7. These are amplified by tube T_2 , and are applied to the output circuit of tube T_1 in such phase as to oppose the distortion generated in tube T_1 . It is desirable, though not necessary, that R_2+R_3 be large compared to the impedance of the signal source so that the gain at T_1 will not be materially reduced through inverse feedback. The function of tube T_2 , it is emphasized, is a compensating one since it acts to eliminate a portion of the distortion without material loss in gain of T_1 .

An illustrative numeral computation will show the advantage of my circuit. Assume an amplifier with a gain of 10 and 10% distortion. If approximately 1% distortion is desired, conventional inverse feedback calls for a 10 to 1 reduction in gain of the amplifier. However, by associating another tube T_2 with the same characteristics, in accordance with the teachings of my invention the lower level of distortion may be attained without materially reducing the original gain. There are many uses to which my invention may be put. For example, in a stage supplying power to a load such as a loud-speaker, the

tube T₁ may be the power tube and tube T₂ can be a much smaller tube supplying power only when T₁ distorts. Again, in a stage driving a diode voltmeter or other non-linear load, tube T₂ may be the triode portion of a diode-triode, or twin triode, and the distortion resulting from the non-linear load may be reduced in this fashion. The present invention may, also, be used to good advantage in a logarithmic voltmeter in which AVC (automatic volume control) bias is supplied by a diode rectifier to an amplifier driving the diode. For large signal inputs the driving amplifier may be operating with considerable distortion due to high AVC bias. The amplifier in such case may be replaced by the present circuit with resultant reduction in distortion.

While I have indicated and described a system for carrying my invention into effect, it will be apparent to one skilled in the art that my invention is by no means limited to the particular organization shown and described, but that many modifications may be made without departing from the scope of my invention, as set forth in the appended claims.

What I claim is:

1. In combination with a signal amplifier provided with input and output electrodes, a signal input circuit connected to the input electrodes, an output load element connected to the output electrodes, a path connected between said output circuit and the signal input circuit, said path having an impedance which is sufficiently large to prevent negative feedback, an auxiliary electron discharge device provided with at least an input electrode and an output electrode, means for connecting the latter output electrode to the output circuit of said amplifier, said load element connecting the output electrodes of said amplifier and auxiliary device in parallel, and means for connecting the input electrode of said auxiliary device to a point on the said path which is of substantially zero signal potential, but which has an appreciable harmonic distortion potential.

2. In combination, a pair of electron discharge devices, each device having at least an input electrode and an output electrode, a common output load resistor connecting said output electrodes of both said devices in parallel, a resistive path connecting the output electrode and input electrode of one of said devices, a signal input circuit con-

nected to the input electrode of said one device, a signal output circuit connected across said output load resistor, and means for applying to the input electrode of the second device distortion voltage derived from a point on the resistive path which is at zero signal potential.

3. In combination with an alternating current amplifier having input and output electrodes and a path between the output and input thereof, a resistive element in said path, a point on said element being chosen such as to have substantially zero potential at the fundamental frequency of the amplified alternating current but a substantial potential at harmonic frequencies of said current, an electron discharge device having a control grid and output electrode, means connecting the grid to said point, and a common output resistor connecting said amplifier output electrode and device output electrode in parallel.

4. In combination with a signal amplifier provided with input and output electrodes, a signal source connected to the input electrodes, an output circuit including an output resistor connected to the output electrodes, a resistive divider connected between said output circuit and the signal input circuit, an auxiliary tube provided with at least an input electrode and an output electrode, means for connecting the latter output electrode to the output circuit of said amplifier, said output resistor connecting the output electrodes of the amplifier and auxiliary tube in parallel, and means for connecting the input electrode of said auxiliary device to a point on said divider which is of substantially zero signal potential, but which has an appreciable harmonic distortion potential.

5. In combination, a pair of electron discharge tubes, each tube having at least an input electrode and an output electrode, a common output load resistor connecting both output electrodes in parallel, a voltage divider connecting the output electrode and input electrode of one of said tubes, a signal input circuit connected to the input electrode of said one tube, a signal output circuit connected across said output load resistor, and means for applying to the input electrode of the second tube distortion voltage derived from a null point on the divider as regards signal frequencies.

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