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R. C. MATHES

AMPLIFIER CIRCUITS

Filed Nov. 7, 1919

Fig. 1

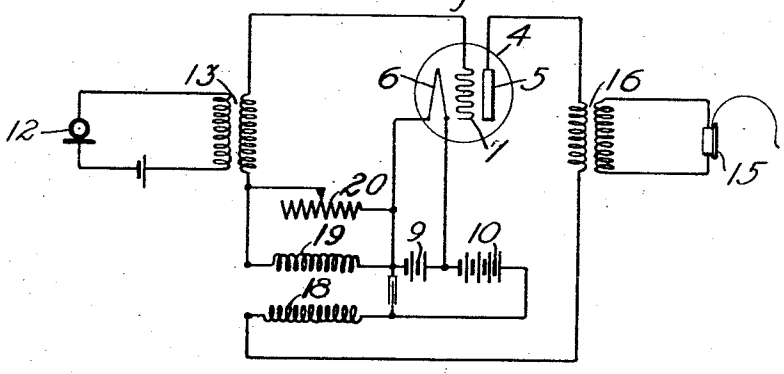


Fig. 2

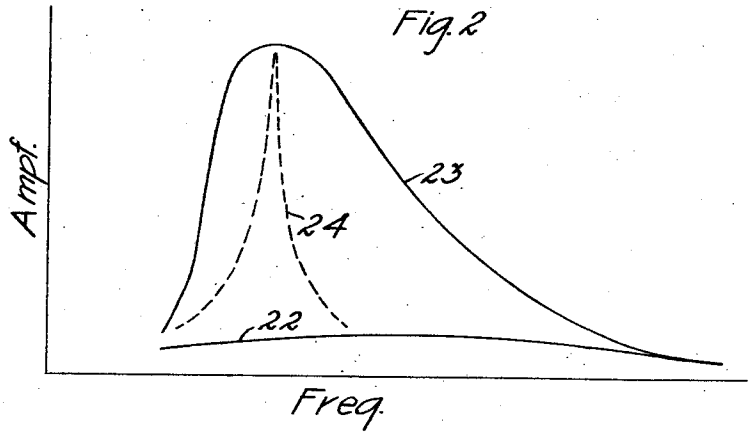
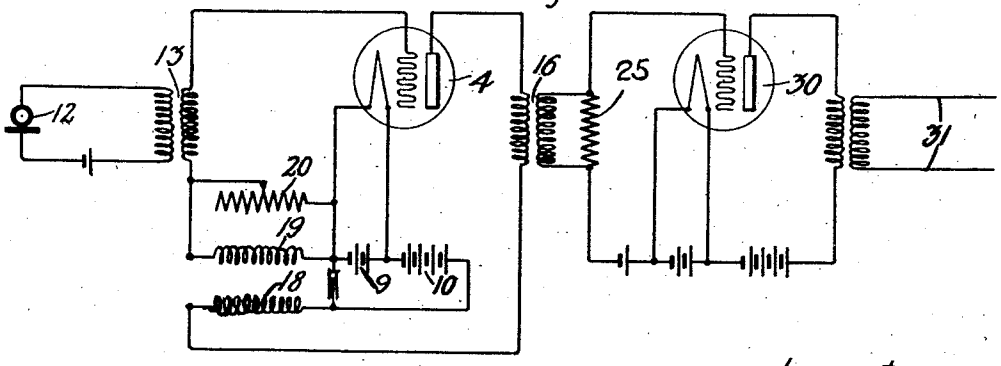


Fig. 3



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UNITED STATES PATENT OFFICE.

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AMPLIFIER CIRCUITS.

Application filed November 7, 1919. Serial No. 336,351.

This invention relates to amplifier circuits and has for an object the provision of means for increasing the amount of amplification that may be secured from an amplifier, particularly of the audion type.

As is well known in the art, a vacuum tube of the three-electrode type may be employed for amplifying currents since any currents impressed on the control electrode of the tube will appear in amplified form in the output circuit of the tube. It is also well known that the output and input circuits of the tube may be associated so that a portion of the output energy may be fed back into the input circuit to be reamplified, thereby greatly increasing the degree of amplification which may be obtained from a tube of a given type. Such arrangements applied to a single tube have, in the past, given greatly increased amplification at a single or very narrow range of frequencies resulting in an amplifier of a highly selective character. This invention contemplates associating the output and input circuits through a mutual impedance or translator of uniform efficiency over a broad range of frequencies, thereby greatly broadening the field of usefulness of such devices. This result is secured preferably by a transformer, one winding of which is placed in the output circuit of the tube and the other winding in the input circuit of the tube; one of the windings being shunted by a resistance. It is found, furthermore, that it is necessary to limit the amount of energy transferred back in order to prevent the generation of undamped oscillations. One, and the preferred way of limiting the degree of feed back, is to make this resistance adjustable, as the increased amplification due to feed back will be zero when this resistance is zero, and a maximum when adjusted just below the critical value which produces singing.

This invention will be better understood by reference to the following detailed description taken in connection with the accompanying drawings, in which Fig. 1 represents the preferred form of the invention; Fig. 2 represents amplification curves of a vacuum tube amplifier; and Fig. 3 represents this invention applied to a two stage amplifier set.

Referring to Fig. 1, 4 is a vacuum tube having an anode 5, a cathode 6 and a control electrode 7. Heating current for the cathode 6 is supplied by a battery 9. Current for the output circuit of the tube is supplied by source of voltage 10. 12 is a source of currents to be amplified which is associated with the input circuit of the amplifier by means of a transformer 13. A suitable receiving device 15 is associated with the output circuit of the amplifier by means of a transformer 16 so that the device 15 will receive signals from source 12 that have been amplified by tube 4.

In order to increase the amount of amplification produced by tube 4, means are provided for feeding back to the input circuit of the tube a portion of the amplified energy in the tube's output circuit. This may be accomplished by inserting the primary winding 18 of a transformer in the output circuit of the tube and by inserting the secondary 19 of the transformer in the input circuit of the tube. A resistance 20 is shunted around the winding 19 of the feed-back transformer in order to give the transformer practically uniform translating efficiency over a broad range of frequencies. This resistance is further made adjustable so that the degree of feed back may be controlled to any desired degree and thereby prevent the tube from singing or generating alternating current,—a condition that would be undesirable in the case of a vacuum tube used to repeat signals without distortion. It is desirable that the value of this resistance 20 should be adjusted so that it is just below the value which will permit the tube to sing. With this adjustment the maximum amount of amplification is secured from the tube, while still preventing the tube from singing.

Fig. 2 illustrates amplification curves for a vacuum tube in which the ordinates represent the degree of amplification obtained for an incoming impulse of a given strength and the abscissæ represent various values of frequency the impulse may have. Curve 22 represents the amount of amplification that may be obtained from a vacuum tube in which no feed-back is employed and may therefore represent the amplification curve of tube 4 with resistance 20 equal to zero thereby providing a short circuit for winding 19. Curve 23 represents the amplification curve such as the tube 4 may have when the feed-back connection is employed in ac-

cordance with this invention. In one case where the value of resistance 20 was 2500 ohms, the ratio of output current to input current was 40 for the peak of the curve 23 which represented frequencies of the order of 400 to 600 cycles. Heretofore feed-back amplifiers have had amplification curves such as curve 24 of Fig. 2, where the greatly increased amplification results only for a single frequency or a very narrow range of frequencies. As shown by the relative values of the ordinates of curves 22 and 23 the feed-back connection of this invention causes an enormous increase over a considerable range of frequencies in the amount of amplification that may be secured from the tube. The degree of uniformity with which curve 23 is increased over curve 22 at various frequencies depends on the refinement of design of the feed-back transformer and also on the uniformity of impedance of the receiving device to which the output circuit of tube 4 is connected. The most uniform characteristic will be obtained when the receiving device presents a simple resistance impedance.

One way in which the feed-back amplifier may be made to work into a receiving device of uniform impedance is to associate the output circuit of the feed-back amplifier with the input circuit of a second amplifier. Such an arrangement is shown in Fig. 3 where transformer 16 has its secondary winding connected in the input circuit of an amplifier 30 which is located between tube 4 and the outgoing line 31. The input impedance of tube 30 as seen from the input of transformer 16 closely approximates a simple resistance impedance of constant value due to the presence of the resistance element 25 in shunt to the secondary winding of transformer 16. A substantially uniform characteristic will therefore be obtained over a wider range of frequencies by the use of the circuit arrangement of Fig. 3, even though the load connected to the outgoing line 31 has an impedance highly variable with frequency.

What is claimed is:

1. In an electric system, a vacuum tube having an input circuit and an output circuit, a source of signals to be amplified, a transformer having a plurality of windings, one of said windings being associated with said source, another of said windings being associated with said input circuit, a second transformer having a plurality of windings, one of the windings of said second transformer being in said output circuit, another of the windings of said second transformer being in said input circuit, and means comprising a resistance in shunt to the winding of said second transformer in said input circuit of such value as to limit the amount of energy transferred through said second transformer sufficiently to prevent the generation of oscillations by said tube.

2. In an electric system, a vacuum tube having an input circuit and an output circuit, means for supplying to said input circuit currents to be amplified, means comprising a transformer for feeding back to said input circuit a portion of the amplified currents in said output circuit, and an adjustable resistance in shunt to a winding of said transformer, said resistance being adjusted to a value just below the critical value which will produce singing.

3. In an electric system, a vacuum tube having an input circuit and an output circuit, a transformer having a winding in said output circuit and a winding in said input circuit, and means for giving said transformer a substantially uniform translating efficiency over a broad range of frequencies simultaneously transmitted through said tube, while preventing said tube from generating sustained oscillations.

4. In an electric system, a vacuum tube having an input circuit and an output circuit, a transformer having a winding in said output circuit and a winding in said input circuit and means comprising a resistance in circuit with a winding of said transformer for making the translating efficiency of said transformer substantially uniform over a broad range of frequencies simultaneously transmitted through said tube, while preventing said tube from generating sustained oscillations.

5. In an electric system, a vacuum tube having an input and an output circuit, a source of waves applied to said input circuit, coupling means for feeding energy, corresponding in frequency to said waves, from said output circuit back to said input circuit less than the amount necessary to generate sustained oscillations, and a second vacuum tube having its input circuit associated with the output circuit of said first mentioned tube, said input circuit of said second vacuum tube being designed to have a substantially pure resistive impedance.

6. In an electric system, a vacuum tube having an input circuit and an output circuit, a transformer for transferring energy from said output circuit to said input circuit, and means for causing the impedance of said input circuit as viewed from said output circuit through said transformer to approximate a pure resistance over a wide range of frequencies, while preventing said tubes from generating sustained oscillations.

7. In an electric system, a vacuum tube having an input circuit and an output circuit, means comprising a translator of uniform efficiency over a wide range of frequencies for transferring energy from said output circuit to said input circuit, and a resistance in shunt to a portion of said trans-

lator, said resistance being of such value that the combination of said translator and said resistance provides a substantially uniform amount of feed-back action over a wide range of frequencies.

8. In an electric system, a vacuum tube amplifier having an input circuit and an output circuit, a transformer for transferring energy from said output circuit to said input circuit, and a resistance in shunt to a winding of said transformer of such a value as to prevent said tube from generating sustained oscillations.

9. In combination a feed back amplifier comprising means for producing a substantially uniform feed-back action over a broad range of frequencies, an outgoing line having an impedance varying with frequency, and means between said amplifier and said line for preventing said line of variable impedance from distorting the feed back amplification characteristic of said amplifier.

10. In combination an amplifier comprising means for producing a feed back action from its output circuit to its input circuit too weak to cause sustained oscillation, an outgoing line having an impedance varying with frequency, and means between said amplifier and said line for causing said amplifier to amplify independently of the variable characteristic of said line.

11. In combination a feed back amplifier having an output circuit and an input circuit, and a receiving line coupled to said output circuit and having an impedance approximating a pure resistance.

12. In combination, a feed back amplifier having an input circuit and an output circuit and means for producing a feed-back action from its output circuit to its input circuit too weak to cause sustained oscillation, an outgoing line, a transformer having a winding in said output circuit, and a winding in said line, and a resistance in shunt to the winding of said transformer in said line.

13. In combination, a feed back amplifier having input terminals and output terminals and means for causing a substantially uniform amount of feed back action over a broad range of frequencies, a receiving device, connections between said output terminals and said device, and a resistance in shunt to said connections.

14. In combination a vacuum tube amplifier having an input circuit and an output circuit, a transformer of high mutual impedance and low shunt capacity for feeding back into said input circuit a portion of the energy in said output circuit, and a resistance in shunt to a winding of said transformer, said resistance being of such value as to prevent said tube from generating oscillations.

In witness whereof, I hereunto subscribe my name this 3rd day of November, A. D. 1919.

ROBERT C. MATHES.