Jan. 13, 1931. D. G. GRIMLEY 1,788,714

HIGH AND LOW FREQUENCY TRANSMISSION CIRCUITS

Filed Sept. 15, 1926

Fig. 1.

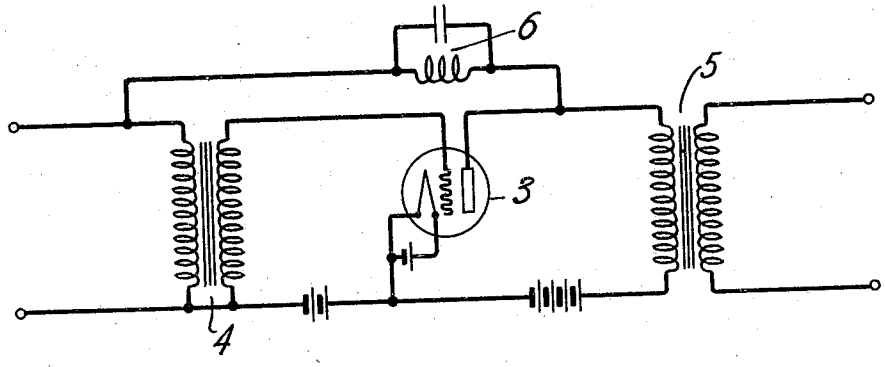
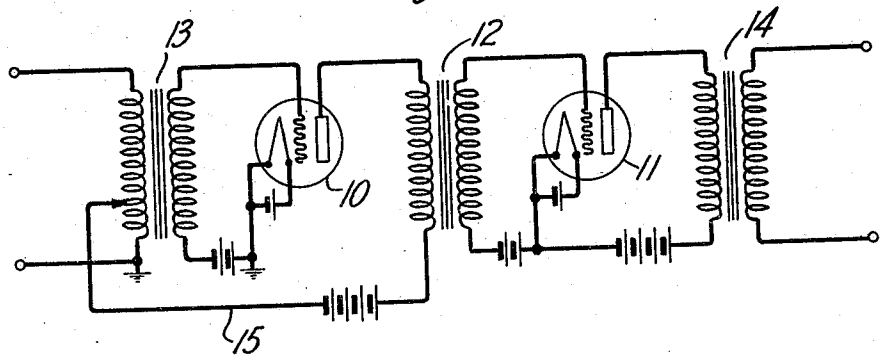


Fig. 2.



Inventor:
Donald G. Grimley.

by W. Griggs Atty.

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UNITED STATES PATENT OFFICE

DONALD G. GRIMLEY, OF RIDGEWOOD, NEW JERSEY, ASSIGNOR TO BELL TELEPHONE LABORATORIES, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK

HIGH AND LOW FREQUENCY TRANSMISSION CIRCUITS

Application filed September 15, 1926. Serial No. 135,508.

This invention relates to electrical transmission circuits and particularly to circuits for amplifying waves of a large range of frequencies.

An object of the invention is to control the transmission characteristics of amplifier circuits.

Another object of the invention is to obtain uniform amplification over a large range of frequencies.

In a preferred embodiment this invention comprises a two-stage electron discharge amplifier with a feed-back connection from the primary of the interstage transformer to the primary of the input transformer of the first stage. By properly proportioning the inductance of the interstage transformer with respect to its distributed capacity and the input capacity of the second stage, it is possible to obtain a feed-back which will reinforce the amplification of the waves in both the lower and upper portions of the frequency range so as to obtain substantially uniform amplification over a wide range of frequencies.

With the ordinary arrangement of transformers in amplifier circuits, it is difficult to obtain uniform amplification over a wide range of frequencies due to the effect of the impedance of the transformers and to the shunting effect of the electrode capacity of the amplifier tubes. This loss in amplification is particularly noticeable in the upper and lower portions of the frequency range and is overcome by the regenerative action of the circuit of this invention, above described.

In the arrangement of this invention, the inductance of the interstage transformer is tuned with the transformer distributed capacity and the input capacity of the tube of the second stage at an intermediate frequency of the range of frequencies to be amplified. This arrangement gives the transformer a comparatively high voltage amplification at the resonant frequency, which is desirable for the efficient operation of the second stage; and produces a feed-back at frequencies both above and below the resonant frequency, which increases the amplification of the first stage to counteract the lower efficiency of the transformer for frequencies in those ranges.

While this invention is described in connection with a particular circuit arrangement it should be understood that the general principles may be applied to various modified circuits without departing from the spirit of the invention. For example, the tuned circuit may be obtained by the use of circuits other than a second amplifier stage and the voltage reversal necessary for obtaining an aiding feed-back may be obtained by the use of a tertiary winding or by making the connection to the secondaries of the transformers instead of to the primaries. Various other modifications will be readily suggested to those skilled in the art.

This invention can be more readily understood by reference to the following detailed description in connection with the drawing in which, Fig. 1 shows a simple amplifier circuit illustrating the general principles of this invention and Fig. 2 shows a two-stage amplifier circuit embodying the principles of the invention.

Referring first to Fig. 1 there is shown a vacuum tube amplifier 3 to which waves to be amplified are supplied through an input transformer 4 and which has its output terminals connected to the primary of an output transformer 5. Filament heating, grid biasing and plate batteries are connected in the usual manner.

Connected between the anode of the tube 3 and one terminal of the primary winding of input transformer 4 is a tuned circuit 6. This connection provides a feed-back (or regenerative) connection which may be made aiding by properly poling the windings of

the transformer 4. The amount of feed-back will be in part determined by the impedance of the circuit 6. Thus, there will be no feed-back at the frequency at which the circuit 6 is tuned as the impedance of the circuit is practically infinite at its resonant frequency, while there will be appreciable feed-back at other frequencies.

In this way, by designing the circuit to be resonant at a mid-frequency of a band of frequencies to be amplified, appreciable feed-back may be obtained both above and below the resonant frequency. This will tend to increase amplification of the circuit for waves in those ranges of frequencies. This increased amplification will tend to neutralize the natural inefficiency of the amplifier in the lower and upper frequency ranges so as to give a substantial uniform transmission over a wide range of frequencies, or the amount of feed back may be regulated by properly choosing the constants of the circuit so as to give any desired frequency-amplification characteristic.

In the circuit of Fig. 2 the tuned circuit for controlling the feed-back is obtained by the proper choice of inductance for the interstage transformer with respect to the input capacity of the tube of the second stage. The circuit of Fig. 2 comprises two vacuum tube amplifiers 10 and 11 connected in tandem through an interstage transformer 12. Each tube is supplied with the usual cathode heating, grid biasing and plate batteries. Waves to be amplified are supplied to the input terminals of the first tube 10 through the input transformer 13 and the output terminals of the second stage tube 11 are connected to the primary of an output transformer 14.

Feed-back is obtained by including a portion of the primary winding of the input transformer 13 in the connection 15 from the primary of the interstage transformer to the cathode of the tube 10. This feed-back is made regenerative by properly poling the windings of the input transformer. Since the output circuit of the tube 10 is in effect a tuned circuit consisting of the mutual inductance of the interstage transformer 12 in parallel with its distributed capacity and the capacity of the input terminals of the second stage tube 11 this gives an arrangement similar to that of Fig. 1. By making this parallel circuit resonant at the mid frequency of the range of frequencies to be amplified, it is possible to obtain increased amplification in both the lower and upper portions of the range to compensate for the natural lower efficiency in those portions produced by the action of the transformers, and thus to give a uniform over-all characteristic. By making the input transformer 13 resonant at the same frequency this compensating effect is accentuated.

While the circuits of Figs. 1 and 2 are similar, one essential difference should be noted, namely, in the circuit of Fig. 2 the output of the amplifier is taken from the circuit which controls the feed-back instead of from a separate circuit.

Obviously the connections are such that if the tube 10 is the second stage of a multi-stage amplifier the plate current for that tube may be drawn from the plate battery of the preceding stage.

What is claimed is:

1. An amplifier comprising a plurality of stages each having an output circuit and a capacitive input circuit, a transformer having one winding connected in the output circuit of one stage and a second winding connected in the input circuit of a succeeding stage effectively in shunt with the input capacity thereof, and means for securing substantially uniform amplification by said amplifier of impressed waves of a wide range of frequencies, said means comprising a feed-back circuit interconnecting the output circuit and the input circuit of said one stage and including therein one of the transformer windings and the capacity effectively in shunt therewith, the inductance of said transformer and said shunt capacity having such relative values as to make said feed-back circuit offer a low impedance to waves of frequencies in the lower and upper portions of said range, and a higher impedance to waves of intermediate frequencies.

2. In combination, an electron discharge amplifying device having an input and an output circuit, a second discharge electron discharge device having an input and an output circuit, a transformer comprising windings coupling the output circuit of the first-mentioned device to the input circuit of said second device, the inductance of said transformer and the capacity effectively in shunt therewith forming a resonant circuit tuned to an intermediate frequency of the band of waves to be amplified by said combination, and means for securing substantially uniform amplification by said combination of said waves over a wide frequency range, said means including a feed-back circuit inter-connecting the output and input circuits of said first mentioned device and effectively including therein said resonant circuit.

3. A multi-stage amplifier comprising an electron discharge device having input and output terminals in each stage, an interstage transformer having a primary winding connected to the output terminals of a device in one stage and a secondary winding connected to the input terminals of a device in a subsequent stage, said transformer being designed to form a tuned circuit with the capacity of the input terminals of said second device at a mid-frequency of a wide

band of frequencies to be amplified, a second transformer having a secondary winding connected to the input terminals of the first mentioned device and a primary winding, and a connection from the primary winding of said interstage transformer to the primary winding of said second transformer for producing a feed-back connection to give a substantially uniform amplification of waves by said amplifier throughout said range of frequencies.

4. An amplifier circuit comprising an electric discharge device having an input and an output circuit, a capacitive circuit, a transformer having one winding in said output circuit and another winding in said capacitive circuit effectively in shunt to the capacity thereof, the mutual inductance of said transformer and the capacity effectively in shunt therewith including the distributed capacity of the transformer windings being tuned to a mid-frequency of a wide band of frequencies to be amplified, and means for securing substantially uniform amplification by said amplifier circuit of waves of a wide range of frequencies extending on either side of said mid-frequency, said means comprising a feed-back circuit connecting the output circuit of said device to the input circuit thereof and including in series therein one winding of said transformer and the capacity effectively in shunt therewith.

5. A multi-stage amplifier comprising an electric discharge device having an input and an output circuit in each stage, an interstage transformer having a primary winding connected to the output circuit of one device and a secondary winding connected to the input circuit of a second electric discharge device in a subsequent stage, said transformer being designed to form a tuned circuit with the capacity of the input circuit of said second device at a mid-frequency of a wide band of frequencies to be amplified, and means for securing substantially uniform amplification by said amplifier of said waves over the major portion of said band, said means comprising a feed-back connection from the output circuit of said one device to the input circuit thereof and including therein one winding of said interstage transformer and the capacity effectively in parallel therewith.

6. An amplifier circuit comprising an electric discharge device having an input and an output circuit, an input transformer having a secondary winding connected to said input circuit and a primary winding connected to a source of waves, another circuit, an output transformer having a primary winding connected to said output circuit and a secondary winding connected to said other circuit, the mutual inductance of said output transformer and the capacity effectively in shunt therewith including the distributed capacity of the output transformer winding being tuned to a mid-frequency of a wide band of frequencies in the waves from said source to be amplified, and means for securing substantially uniform amplification by said amplifier of said waves over a wide frequency range within said band, said means comprising a feed-back connection from the primary winding of said output transformer to the primary winding of said input transformer and including said mutual inductance and the capacity effectively in shunt therewith.

7. An amplifier circuit comprising an electric discharge device having an input and an output circuit, another circuit having a capacitive input, a transformer having a primary winding in said output circuit and a secondary winding in the input of said other circuit effectively in shunt with the capacity thereof, the mutual inductance of said transformer and the capacity effectively in shunt therewith including the distributed capacity of the transformer windings being tuned to a mid-frequency of a wide band of frequencies to be amplified, and means for effecting regenerative amplification to a desired degree by said amplifier circuit of waves of frequencies above and below said mid-frequency while substantially preventing regenerative amplification of waves of said mid-frequency, said means comprising a feed-back connection between said output circuit and said input circuit and including one winding of said transformer and the tuned circuit formed therewith.

8. An amplifier comprising a plurality of stages each having an output circuit and a capacitive input circuit, a transformer having one winding connected in the output circuit of one stage and a second winding connected in the input circuit of a succeeding stage effectively in shunt with the capacity thereof, and means for controlling the amplification characteristic of the amplifier to a desired degree, said means comprising a tuned feed-back circuit connecting the output circuit of said one stage to the input circuit thereof, said tuned circuit including as an element thereof the inductance of said transformer.

9. In combination, a source of waves of a wide band of frequencies, an electron discharge amplifying device having input terminals connected to said source and output terminals, an output transformer comprising a primary winding connected to said output terminals and a secondary winding, an outgoing circuit for the amplified waves connected to said secondary winding effectively in shunt with the mutual inductance of said transformer, and means for securing substantially uniform amplification by said amplifying device of the waves from said source over a wide frequency range, said

means comprising a circuit for feeding back waves from the output terminals of said one device to the input terminals thereof, and including a circuit tuned to an intermediate frequency within said range, said tuned circuit including as an element thereof the mutual inductance of said transformer.

In witness whereof, I hereunto subscribe my name this 14th day of September, A. D. 1926.

DONALD G. GRIMLEY.