Jan. 23, 1934. V. D. LANDON 1,944,746

AUDIO FREQUENCY AMPLIFIER

Filed April 20, 1929

Fig. 1.

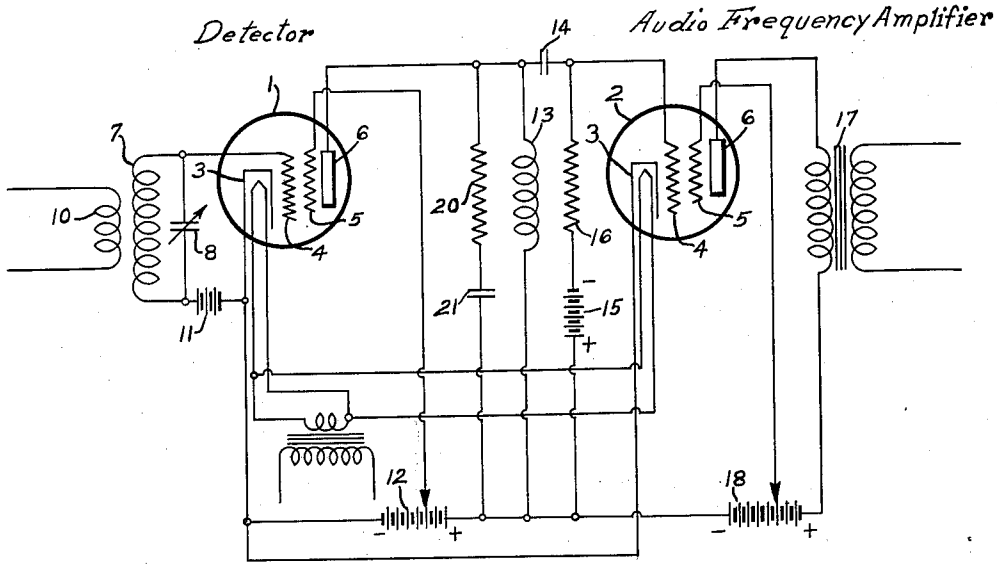
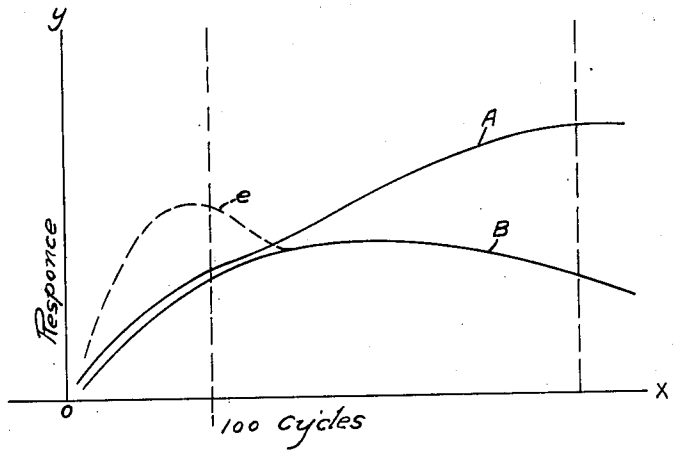


Fig. 2.



INVENTOR
Vernon D. Landon

BY Wesley G. Carr
ATTORNEY

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AUDIO-FREQUENCY AMPLIFIER

Vernon D. Landon, East Pittsburgh, Pa., assignor to Westinghouse Electric & Manufacturing Company, a corporation of Pennsylvania

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2 Claims. (Cl. 179—171)

My invention relates to amplifiers and it has particular relation to audio-frequency amplifiers of the impedance, or resistance-coupled type.

During the process of designing an impedance-coupled audio-frequency amplifier utilizing four-electrode tubes of the type shown in the patent to Schottky, No. 1,537,708, I found that it was difficult to produce, by known methods, an amplifier having a flat characteristic curve between 100 and 5,000 cycles, the range necessary for satisfactory musical and voice reproduction.

An analysis of the situation revealed that the tubes with which I was experimenting had a plate impedance of the order of one megohm, while at 100 cycles, the inductive reactance of a commercially feasible coupling-choke was only about 200,000 ohms. Since, as is known to those skilled in the art, only 70% of the possible total voltage will be developed across the output inductor when the inductive reactance thereof equals the plate impedance of the tube, at any given frequency, the voltage available for impressing on the next stage of the amplifier is only about 20% of the maximum when the reactance of the output circuit is of the order mentioned, i. e., 200,000 ohms.

I found it impracticable to substitute a resistor for the coupling-choke since the unavoidable IR drop therein would necessitate the provision of undesirably high potentials from the plate-supply source.

It is, therefore, an object of my invention to provide an impedance-coupled amplifier having a characteristic curve that is substantially flat between 100 and 5000 cycles.

Another object of my invention is to provide a system of impedance-coupling particularly useful in connection with tubes of the four-electrode type.

Another object of my invention is to reduce the size of the choke-core necessary to obtain the above results.

Another object of my invention is to produce a peak in the response curve of an amplifier in the neighborhood of 100 cycles, when this seems desirable by reason of deficiencies in other parts of the apparatus.

In carrying my invention into effect, I connect a resistor in shunt relation to the coupling-choke in an impedance-coupled amplifier in order to reduce the amplification at the higher frequencies. The resistor, however, also tends to lower the amplification at frequencies in the neighborhood of 100 cycles and, for that reason, I find it advisable to insert a small condenser in series therewith. The reactance of the condenser is substantially negligible at the higher frequencies, but it is sufficient to raise the low-frequency response of the amplifier to a satisfactory degree.

The novel features that I consider characteristic of my invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and its method of operation, together with additional objects and advantages thereof, will best be understood from the following description of a specific embodiment, when read in connection with the accompanying drawing, in which:

Figure 1 is a diagrammatic view of a portion of a signal-reception system comprising a preferred embodiment of my invention; and

Fig. 2 is a diagram to which reference will later be made in explaining the theory underlying my invention.

The apparatus illustrated in Fig. 1 comprises a thermionic detector tube 1 and a thermionic amplifier tube 2 each having an equi-potential cathode 3, a plurality of grids 4 and 5 and a plate 6. The cathodes may be heated from any convenient source of either alternating current or direct current.

The tube 1 is provided with a tunable input circuit, constituted by an inductor 7 and a tuning condenser 8 which circuit may be coupled to any convenient source 10 of incoming high-frequency signals. In order that the tube 1 shall function as a detector, a biasing battery 11 is provided, whereby the grid potential thereof may be so adjusted that the output current therefrom is distorted.

The detector tube is provided with a source 12 of plate potential, the positive terminal of which is connected to the plate through an output inductor 13. The shield grid 5 of the detector tube is connected to an intermediate point on the plate-potential source in a manner well known to those skilled in the art.

The output circuit of the detector tube is coupled to the control grid 4 of the amplifier tube 2 through a stopping condenser 14.

The amplifier tube is provided with a grid-biasing battery 15, the negative terminal of which is connected to the grid 4 through a resistor 16 of the order of several megohms.

The output circuit of the amplifier tube comprises the primary winding of an audio-frequency transformer 17, or it may, if additional stages are to be used, comprise a coupling-choke (not

shown) analogous to the choke which constitutes the output circuit of the detector tube.

A source 18 of plate potential is provided for the audio-frequency amplifier tube, which source, in commercial radio receiving sets, would be the same as that provided for the detector tube.

The shield grid 5 of the amplifier tube is connected to an intermediate point on the plate-potential source.

The amplifier thus far described is of the well-known impedance-coupled type exemplified by the British patent to H. Green, No. 241,257 and, inasmuch as the coupling choke has a reactance which increases with frequency, the said amplifier tends to unduly accentuate audio frequencies of the order of 5,000 cycles and higher.

The response of such an amplifier is illustrated by the curve A in Fig. 2.

In order that the response at the higher frequencies shall be lessened, a resistor 20, of the order of ¼ megohm, may be connected in shunt to the coupling choke and, if this is done, the response of the amplifier is of the type illustrated by the curve B in Fig. 2.

Such an amplifier, however, is still unsatisfactory, and I have accordingly inserted a small condenser 21, of the order of .0025 to .0075 microfarad capacity, in series with the resistor. This condenser functions to substantially remove the resistor from the coupling network at the lower frequencies, thus increasing the low-frequency response of the amplifier.

The response of an impedance-coupled amplifier, comprising a resistor and a condenser serially connected in shunt to the coupling choke, is indicated by the dotted curve *e* in Fig. 2.

In addition to the effective removal of the shunting resistor from the circuit at low frequencies by the presence of the condenser in series therewith, it seems probable that the condenser cooperates with the coupling inductor to constitute a circuit that is broadly resonant to frequencies in the neighborhood of 100 cycles.

I have illustrated my invention in connection with thermionic tubes of the four-electrode type, principally on account of the fact that the plate impedance of such tubes is so high that ordinary coupling systems cannot be efficiently used with them. My invention, however, is applicable, with substantialy no modification, to thermionic tubes of the usual three-electrode type.

An amplifier constructed according to my invention is principally advantageous in that it has a substantially flat characteristic response-curve at all frequencies necessary for satisfactory voice and music reproduction. In addition, the provision of the relatively inexpensive resistor and condenser in shunt to the coupling reactor permits a marked reduction in size of the latter, with a consequent lowering of the cost of manufacture of the amplifier.

Although I have chosen a particular embodiment of my invention for purposes of illustration, many modifications thereof will be apparent to those skilled in the art to which it pertains. My invention, therefore, is not to be restricted to the specific apparatus illustrated but is to be limited in scope only by the prior art and by spirit of the appended claims.

I claim as my invention:

1. In combination, a thermionic device having an output circuit constituted by an inductor having a reactance of substantially 200,000 ohms at 100 cycles, and a resistor of the order of one-quarter megohms and a condenser of the order of .005 microfarad connected serially in shunt to said inductor, said shunt connection being substantially devoid of inductance.

2. In combination, a thermionic device having an output circuit constituted by an inductor, a resistor and a capacitor connected serially in shunt with said inductor the reactance of said inductor at 100 cycles being substantially four-fifths of the ohmic resistance of said resistor, said shunt circuit being substantially devoid of inductance.

VERNON D. LANDON.