June 30, 1931. A. CARPE 1,811,915

MEANS TO CONTROL CROSS TALK

Filed June 26, 1928

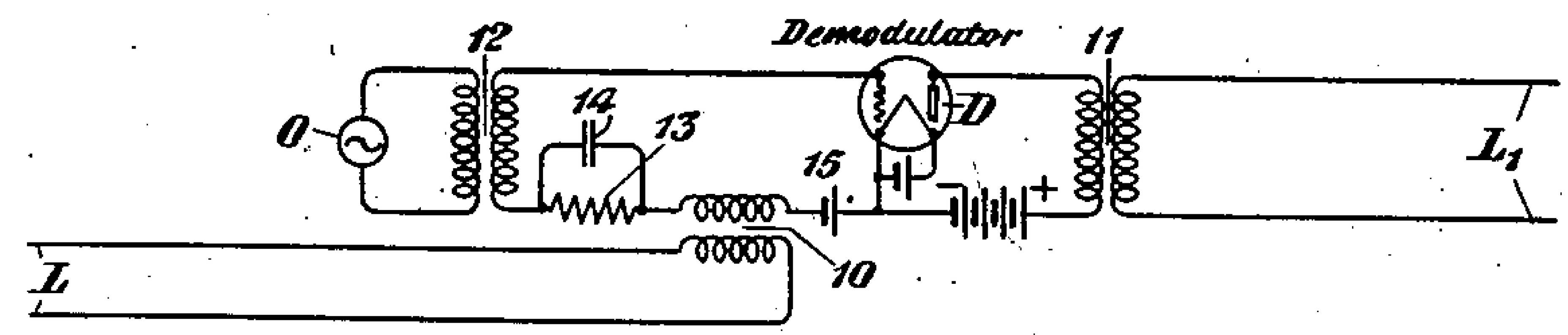

Fig. 1

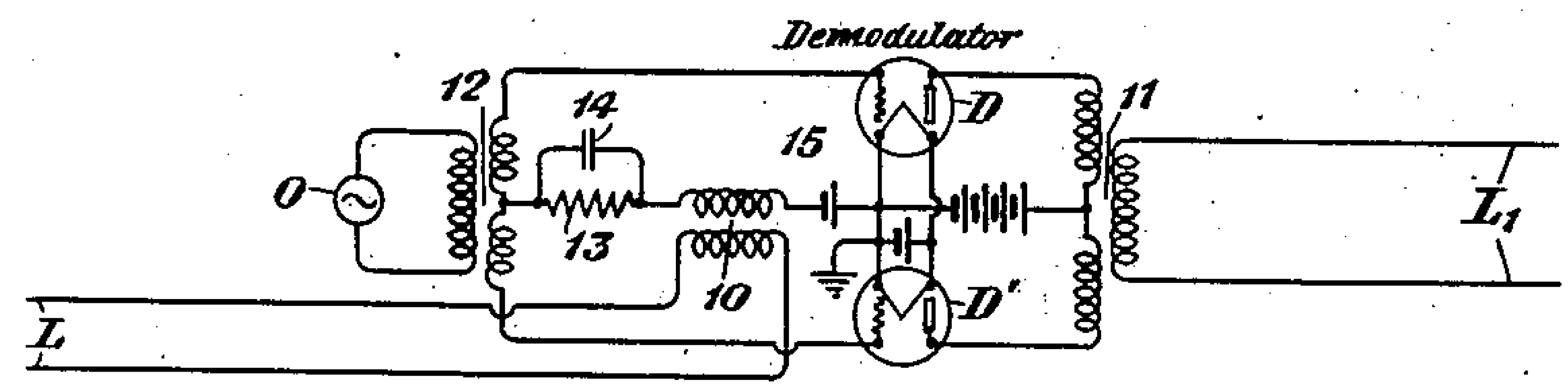

Fig. 2

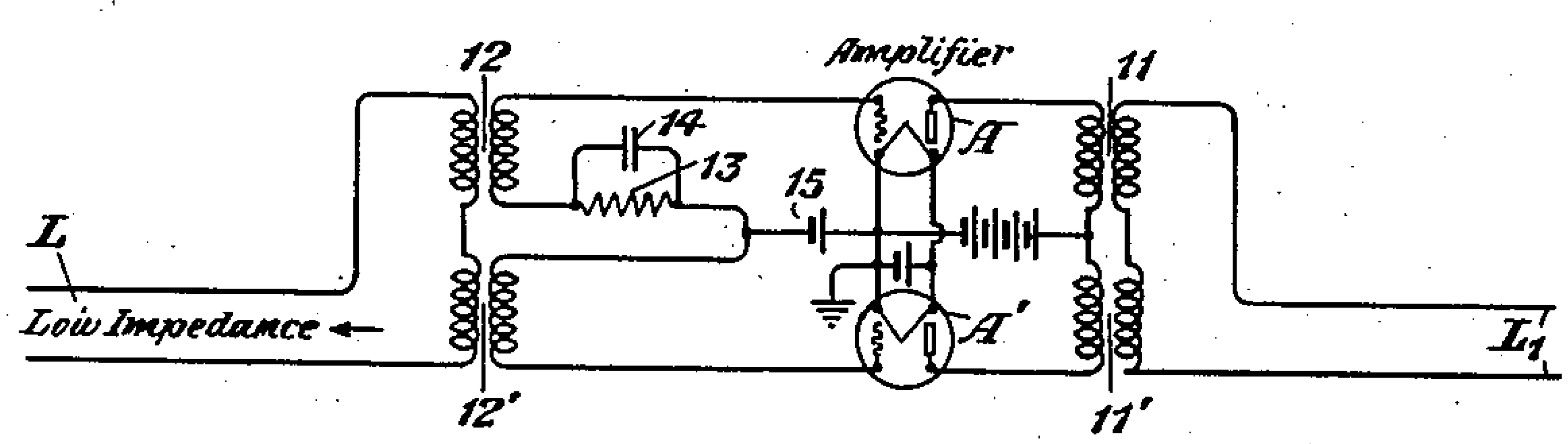

Fig. 3

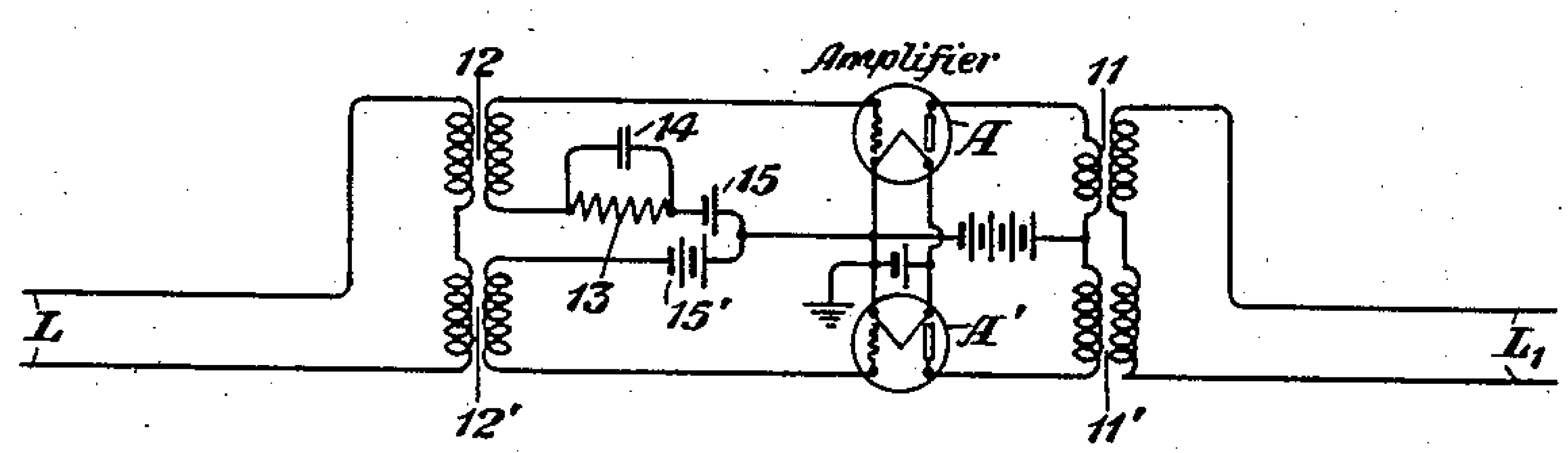

Fig. 4

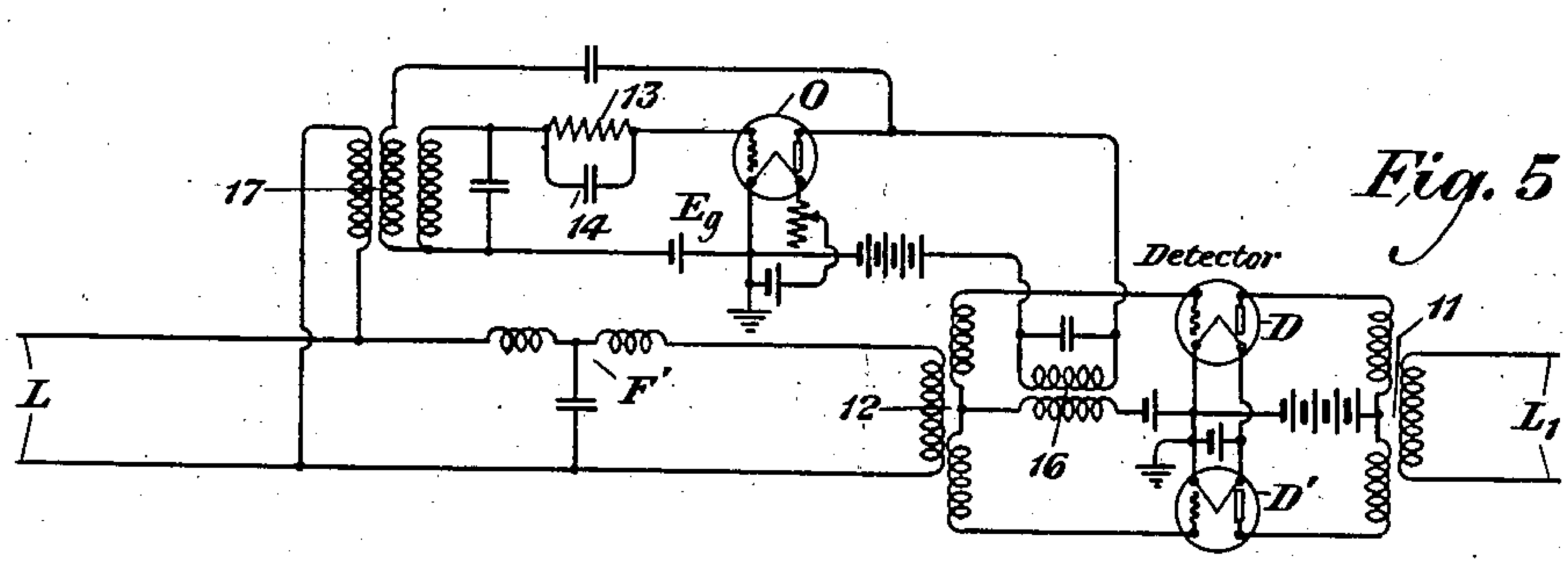

Fig. 5

INVENTOR
A. Carpe

BY

ATTORNEY

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UNITED STATES PATENT OFFICE

ALLEN CARPE, OF NEW YORK, N. Y., ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK

MEANS TO CONTROL CROSS TALK

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This invention relates to transmission circuits, and more particularly to arrangements for reducing cross-talk or interference upon such circuits.

In designing telephone transmission circuits with respect to cross-talk limitations, there are two factors to be taken into consideration,—first, the effect of cross-talk upon the intelligibility of the conversation while talking is taking place, and second, the absence of secrecy or the annoying effect of the cross-talk during gaps in the conversation. The latter factor determines the limiting condition, for the reason that the maximum cross-talk current which would be permissible without rendering the conversation unintelligible will be greater than the maximum cross-talk which may be permitted without rendering such cross-talk understandable or objectionable during gaps in the conversation.

It has heretofore been proposed to eliminate or reduce cross-talk or noise currents from external sources, during such intervals as conversation is not taking place, by providing switching arrangements for normally disabling the circuit for transmission purposes, such disabling means being removed, however, under the control of voice currents when conversation takes place.

It is proposed, in accordance with the present invention, to arrange the receiving apparatus of the carrier channels so that the receiving gain will be appreciably less at small inputs than at normal speech loads. This results in the receiving apparatus discriminating against cross-talk during non-talking intervals, while permitting of proper transmission of the relatively large talking currents.

The invention may now be more fully understood from the following description, when read in connection with the accompanying drawings, in which Figures 1 to 5, inclusive, represent five different circuit arrangements embodying the invention.

Referring to Fig. 1, L designates the connection extending from the carrier receiving apparatus of one channel of the carrier system to the main line upon which the carrier channels are superposed. Included in the circuit L is a demodulator comprising a vacuum tube D, so connected that its input circuit is supplied with signaling current through a transformer 10, the output circuit being connected to an outgoing connection L_1 through a transformer 11. In the arrangement disclosed in Fig. 1, it is assumed that at the distant transmitter station the carrier is suppressed and only the side band is transmitted. Consequently, a source of carrier or beating frequency O is provided and is associated with the input of the demodulator through the transformer 12.

In order to control the effectiveness of the demodulator for currents of different amplitudes, a resistance 13, shunted by a condenser 14, is provided in the grid circuit. The normal biasing of the grid is determined by the usual grid battery 15. The potential applied to the grid by the battery 15 is such that when only the carrier current from the source O is superposed on the grid, the potential from the source 15, when added to the negative potential trapped upon the grid by reason of the operation of the resistance-capacity combination 13—14, will be just sufficient to cause the demodulator to operate on the straight or amplifying part of its characteristic. Under these conditions, the tube D is practically ineffective as a demodulator, as the second power term of the current in its output is either not present or is only present in a very minor degree.

When a signal band of very small amplitude is received, as will be the case when noise currents or cross-talk currents are transmitted into the circuit L, the trapped negative potential upon the grid is but very little increased, and the tube D still remains quite ineffective as a demodulator. When, however, signal bands of large amplitude, such as correspond to voice signals, are impressed upon the grid circuit, the effect of the resistance-capacity combination 13—14 will be such as to trap a very much larger negative potential upon the grid and thereby bias the grid sufficiently negative to cause it to operate in the region of its lower knee. Therefore, a very large second power term appears in the output circuit, and the tube D becomes quite effective as a demodulator.

The time constant of the resistance-capacity combination 13—14 should be such as to prevent fluctuations of gain at frequencies normally occurring in the audio frequency band, but should allow the gain to change sufficiently rapidly so that no appreciable portion of a syllable will be lost when the talker starts to speak, and so that the gain will drop off rapidly at the end of a period of transmission. A time constant of the order of 0.005 to 0.01 second will generally be found satisfactory.

Fig. 2 shows a modified arrangement in which the modulator comprises two vacuum tubes connected in a push-pull circuit. The side band from the circuit L is applied to the common path of the grid circuits of the two tubes through a transformer 10, so that components corresponding to the undetected side band frequencies will be suppressed from the output circuit of the demodulator. The carrier frequency source O is so connected to the grid circuits of the two tubes of the demodulator that the grids of the two tubes will be effectively in series with respect to the carrier current. Consequently, the carrier current is not suppressed from the output circuit of the modulator. As before, the resistance-capacity combination 13—14 and the grid biasing battery 15 are so proportioned that with no side band present and only the carrier current being applied, the demodulator tubes will be operated on the straight or amplifying parts of their characteristics and will be consequently very ineffective as demodulators.

When a side band corresponding to weak signaling currents, such as noise or cross-talk, is received, the negative charge trapped by the resistance-capacity combination will bias the grids but little further negative than under the condition above referred to, and hence the demodulator will be ineffective to produce audible currents corresponding to the noise or cross-talk. When side bands corresponding to strong signals, such as voice currents, are received, however, the negative charge trapped upon the grids of the demodulator will be sufficiently large to shift the point of operation of the tubes to the neighborhood of the lower knee of the characteristic curves, so that the demodulator becomes quite effective to produce audible signaling currents corresponding to the voice waves.

It should be noted that in both Figs. 1 and 2 the resistance-capacity combination 13—14 is so biased as to operate upon a different principle from that of the grid-leak combination frequently employed in connection with the detectors of radio receiving sets. In such detectors, the resistance and capacity of the grid-leak combination are so proportioned as to trap charges due to successive impulses of the carrier frequency, but the resistance must permit the capacity to discharge with sufficient rapidity so that the negative charge upon the grid will vary with the envelope of the high frequency wave; in other words, so that the charge on the grid will vary with the voice frequency wave. In the case of the demodulators herein described, however, the time constant is much larger so that the charge does not vary with the rise and fall of the individual voice waves. On the contrary, the charge is determined by the general level of a train of voice waves and merely varies with changes in the amplitude or volume of the speech as the speaker raises and lowers his voice in talking. It is this adjustment of the resistance-capacity combination that enables the demodulators herein described to discriminate as regards their gain with respect to voice signals and cross-talk. A grid-leak arrangement, such as is employed in a usual radio detector, does not have this characteristic, and the radio will detect, with equal effectiveness, all audible signal frequencies modulated upon a carrier frequency, regardless of the amplitude of the original signal frequency.

Fig. 3 shows the principle of the invention as described above, applied to an amplifier instead of a demodulator. This arrangement is, of course, equally applicable to both voice frequency and carrier frequency systems. In this instance, the circuit L is connected to an amplifier comprising two vacuum tubes A and A′ connected in parallel, so that both tubes are interposed between the circuit L and the circuit L_1. Transformers 12 and 12′, which may consist of windings on a common core, are used to couple the circuit L to the inputs of the tubes A and A′, and likewise, transformers 11 and 11′, which may also have a common core, are used to connect the outgoing circuit L_1 to the two tubes. The secondary winding of one of the output transformers, for example 11′, is reversed with respect to the secondary of the other transformer, with the result that when the two vacuum tube circuits are properly balanced, no transmission takes place between circuit L and circuit L_1.

The normal grid potentials are supplied by means of the C battery 15. These potentials are small, of the same order of magnitude as the interfering voltages which it is desired to suppress. A resistance-capacity combination 13—14, similar to that previously described, is included in the grid circuit of the upper tube A. The function of this resistance-capacity combination is to increase the grid bias of the upper tube whenever the input voltage exceeds that of the biasing battery 15. This change in grid bias will unbalance the circuit, due to the resultant change in plate impedance, and a differential output will be obtained. Obviously, for weak currents, such as noise or cross-talk currents received in the circuit L, which do not, during their positive half cycles exceed in potential the voltage due to the battery 15, the amplifying circuit will be balanced so that no transmission will take place. In response to signals of large amplitude, such as those due to voice currents, however, the grids of the two tubes will go positive for each positive cycle, and the grid of the upper tube will have a negative charge trapped thereon, due to the action of the resistance-capacity combination 13—14. This results in the upper tube being biased differently from the lower tube, so that the system is unbalanced and the amplifier transmits effectively. In order that the change in plate impedance may result in an effective differential output, the impedance of the circuit L_1 should not be too large compared with the plate impedance.

The fact that the grids go positive with each positive cycle, as above described, will result in distortion in case the external impedance of the input circuit is large. In order to substantially eliminate and reduce distortion, the circuit L should be made of low impedance. Each time the grid of a tube goes positive, some current flows between the grid and filament. So long as the grid is negative, no current can flow, and the grid-filament impedance is infinite. As soon as current does flow, however, the grid-filament impedance is reduced to some finite value. The potential drop between the grid and filament, of course, depends upon the grid-filament impedance. When the grid-filament impedance is infinite, the full voltage of the signal applied to the circuit appears between the grid and the filament. When, however, the impedance between the grid and the filament drops to a finite value, the drop between the grid and filament depends upon the ratio between the grid-filament impedance and the impedance looking into the circuit L. The lower the impedance looking into the circuit L is made, the greater will be the proportion of the total signal voltage which appears as the potential drop between the grid and filament. Consequently, by keeping the impedance of the circuit L low, the distortion due to change in the impedance of the grid-filament circuit may be very much reduced, and, in fact, practically eliminated.

An improved circuit, embodying the same principles, is illustrated in Fig. 4. The circuit is generally similar to that of Fig. 3, but differs in the fact that a separate grid polarizing battery is provided for each amplifier tube. The potential of the polarizing battery 15′ for the grid of tube A′ will be that normally used for amplifier tubes. The battery 15 for polarizing the grid of the upper tube A, however, will be such as to produce a smaller grid bias, and, in fact, the grid bias of the upper tube may be zero. In order to balance the two amplifying circuits so as to suppress weak signaling currents and prevent their transmission to the circuit L_1, the secondary winding of one of the output transformers is reversed with respect to that of the other, as in the case of Fig. 3. Furthermore, due to the difference in the biasing potentials applied to the grids of the two tubes A and A′, the normal output impedances of the two tubes will be different; and, consequently, the primary winding of the output transformer 11 of the upper tube is made of fewer turns than the primary winding of the output transformer 11′ of the lower tube.

Under these conditions, the amplifier circuit will be balanced so that no transmission will take place between L and L_1 under normal conditions. For weak signals, such as noise or cross-talk, which do not exceed in amplitude the voltage of the biasing battery 15, the resistance-capacity combination 13—14 will have no effect to change the grid bias of the tube A, and hence the amplifier system will balance out such signals. When signals of large amplitude, such as those due to voice currents, are received, such signals will be transmitted, without distortion, through the lower amplifier A′, due to the fact that the bias on the grid of this tube is a normal amplifier bias. Such signals, when applied to the upper tube, will, as to their positive half cycles, exceed the voltage of the biasing battery 15. Consequently, the resistance-capacity combination 13—14 comes into play to drive the grid of the upper tube more negative and thereby unbalance the circuit, with the result that effective transmission takes place between the circuit L and the circuit L_1.

It should be noted that the impedance looking into the circuit L_1 should not be too high as compared with the output impedance of the upper tube A, so that the voltage amplification due to this branch will decrease with an increase in the plate impedance of the tube A, when the input is greater in amplitude than the voltage of the biasing battery 15.

Fig. 5 shows a slightly different arrangement, in which the control is effected by means of a resistance-capacity combination in a grid circuit of the oscillating tube which supplies the oscillations to a demodulator. Here the circuit L is connected through a transformer 12 to the input of a balanced detector arrangement comprising tubes D and D′, whose output is connected through a transformer 11 to the outgoing circuit L_1. The beating carrier frequency is supplied by a vacuum tube oscillator O, which is connected to the common branch of the grid circuits of the tubes D and D′ through the transformers 16. The resistance-capacity combination 13—14 is connected in the grid circuit of the oscillator O, and the grid circuit of the oscillator is also associated with the incoming circuit L through a transformer 17. This transformer 17 may alternatively be connected across the output circuit L_1 so as to be actuated by the output currents of the demodulators. In this case it is merely necessary that the path from transformer 17 through tube O to transformer 16 be inefficient for all frequencies which may be transmitted through the detector path, and vice versa.

Under normal conditions, when no side band is being received in the circuit L, the grid potential of the oscillator O is determined by the grid battery E_g and the amount of carrier oscillations delivered to the demodulator will be determined by the constants of the circuit and of the transformer 16. The circuit may be so adjusted that under these conditions the oscillations supplied to the demodulator will be of such amplitude as to render it relatively ineffective in the production of signals. When a voice band corresponding to a large signaling current, such as a voice current, is being received, some of this energy is impressed through the transformer 17 upon the grid circuit of the oscillator O. The effect of the resistance-capacity combination 13—14 is to trap a large negative potential upon the grid, which shifts its bias in a negative direction and thus alters the amplitude of the carrier oscillations produced by it. By proper adjustment of the circuit, the demodulator may be caused to operate more efficiently with this different amplitude of carrier than was the case when no signal voltage was impressed upon transformer 17.

If the side band representing a signal of small amplitude, such as noise or cross-talk, is being received, the effect of the capacity combination 13—14 is to drive the biasing potential of the grid of the oscillator but little more negative than under no-load conditions, so that the amplitude of the carrier oscillations is little changed and the demodulator remains relatively ineffective. Hence, for noise or cross-talk currents, the detected output current is very small, but in the case of signal currents of large amplitude, the corresponding detected currents appearing in the circuit L_1 will be large.

If desired, a delay circuit F′ may be included in the circuit L between the connection to the transformer 17 and the connection to the transformer 12 to permit the negative charge to build up on the grid of the tube O before the voice wave arrives at the detector, thus preventing any clipping or discrimination against the initial parts of the voice wave.

It will be obvious that the general principles herein disclosed may be embodied in many other organizations widely different from those illustrated, without departing from the spirit of the invention as defined in the following claims.

What is claimed is:

1. In a transmission system, a transmission circuit, a vacuum tube device associated with said circuit, and means to render the gain of said vacuum tube device appreciably less in response to small received current than in response to normal speech signals, said means comprising a capacity shunted by a resistance in the grid circuit of said tube and cooperating with the rectifying action of the grid filament path in the tube to produce a one-way biasing potential in the grid circuit, said resistance and condenser being so proportioned as to change the bias of said grid in accordance with the amplitude of the received current.

2. In a transmission system, a transmission circuit, a push-pull translating circuit associated with said transmission circuit, said push-pull circuit being normally substantially ineffective to translate signaling currents received from said transmission circuit, a vacuum tube associated with said push-pull circuit, and means to render said push-pull circuit less effective in response to small received current than in response to normal speech signals, said means comprising a capacity shunted by a resistance in the grid circuit of said tube and so proportioned as to change the bias of said grid in accordance with the amplitude of the received current.

3. In a transmission system, a transmission circuit, a vacuum tube device associated with said circuit, means to apply a normal steady biasing potential to the grid of a tube of said device, means to render the gain of said receiver appreciably less in response to small received current than in response to normal speech signals, said last mentioned means comprising a capacity shunted by a resistance in the grid circuit of said tube and cooperating with the rectifying action of the grid filament path in the tube to produce a one-way biasing potential in the grid circuit, said resistance and condenser being so proportioned as to change the bias of said grid in accordance with the amplitude of the received current.

4. In a transmission system, a transmission circuit, an amplifying arrangement comprising a push-pull circuit associated with said transmission circuit and normally so balanced with respect to the transmission circuit as to be substantially ineffective to transmit signaling currents received from said transmission circuit, and means to produce an unbalance of the push-pull circuit in accordance with the amplitude of received signaling current, whereby said amplifying arrangement will be more effective in response to normal voice currents than in response to weak signaling currents.

5. In a transmission system, a transmission

circuit, an amplifying arrangement associated with said transmission circuit and comprising a pair of vacuum tubes arranged in a push-pull circuit, said push-pull circuit being normally so balanced as to be substantially ineffective to transmit signaling currents received from said transmission circuit, and means to produce an unbalance of the push-pull circuit in accordance with the amplitude of received signaling current, said means comprising a capacity shunted by a resistance in the grid circuit of one of said tubes and so proportioned as to change the bias of the grid of said tube in accordance with the amplitude of the received current, whereby said amplifying arrangement will be more effective in response to normal voice currents than in response to weak signaling currents.

In testimony whereof, I have signed my name to this specification this 21st day of June, 1928.

ALLEN CARPE.