

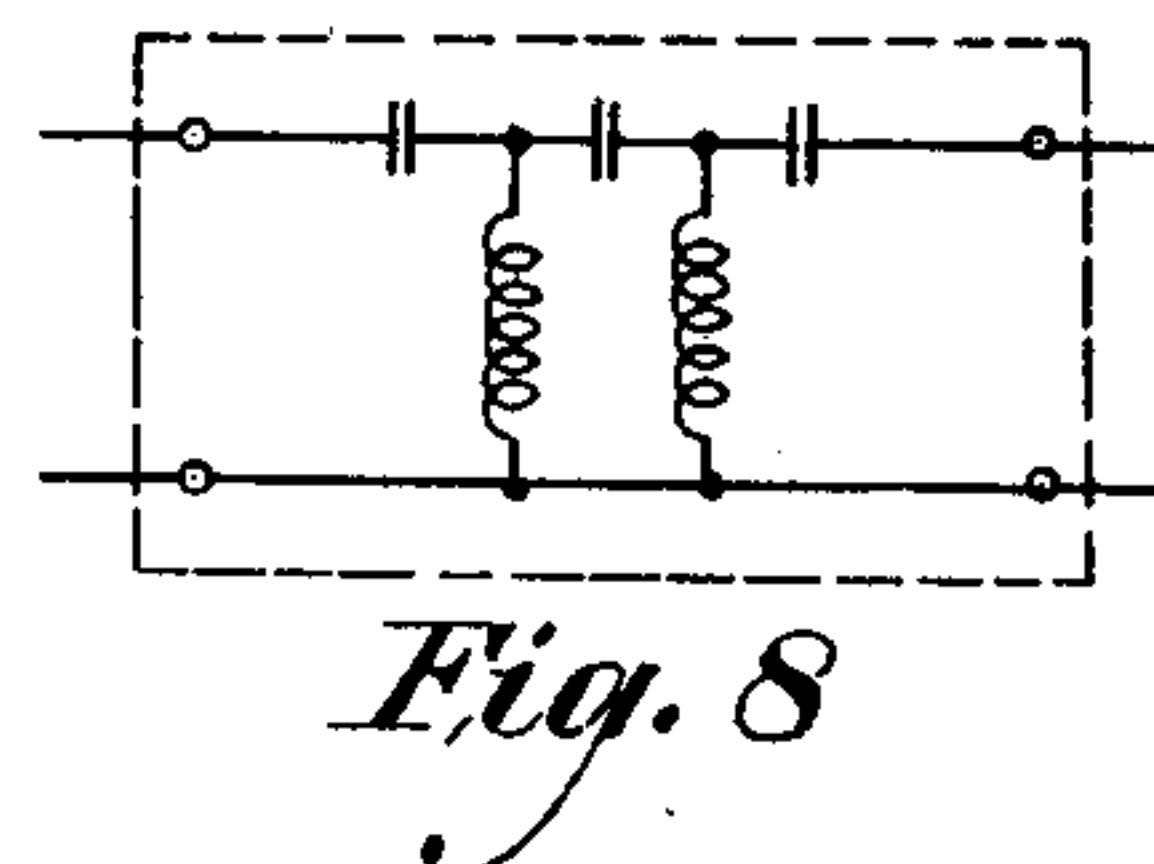
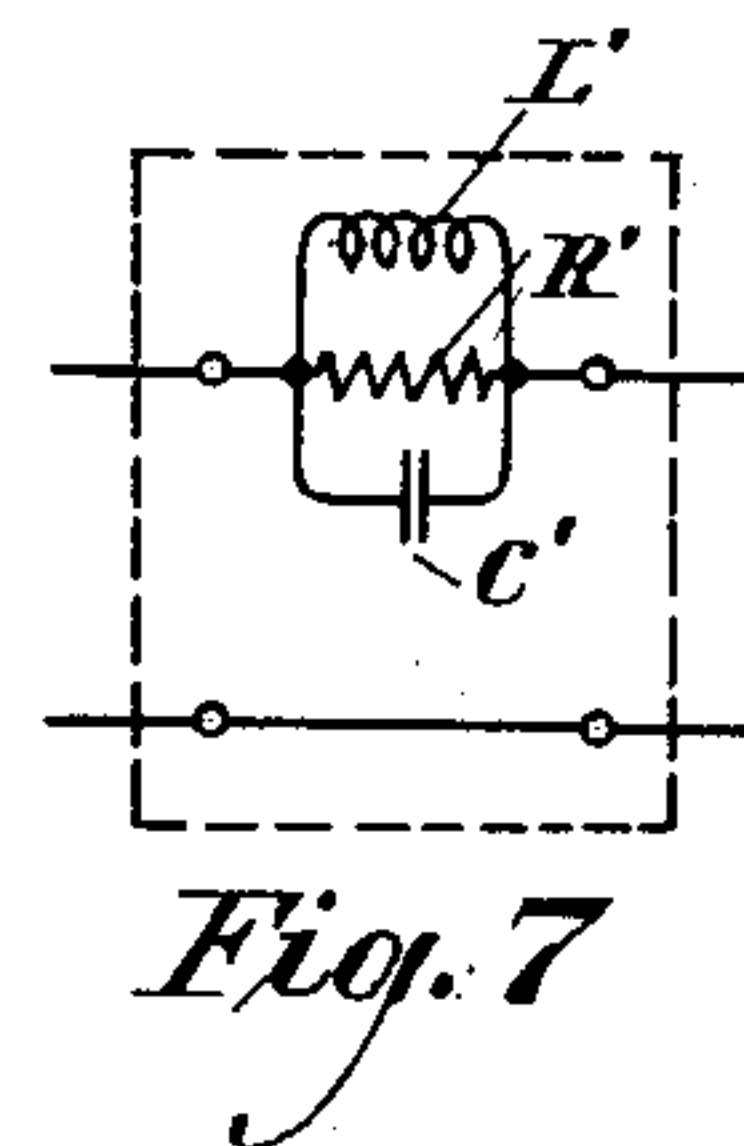
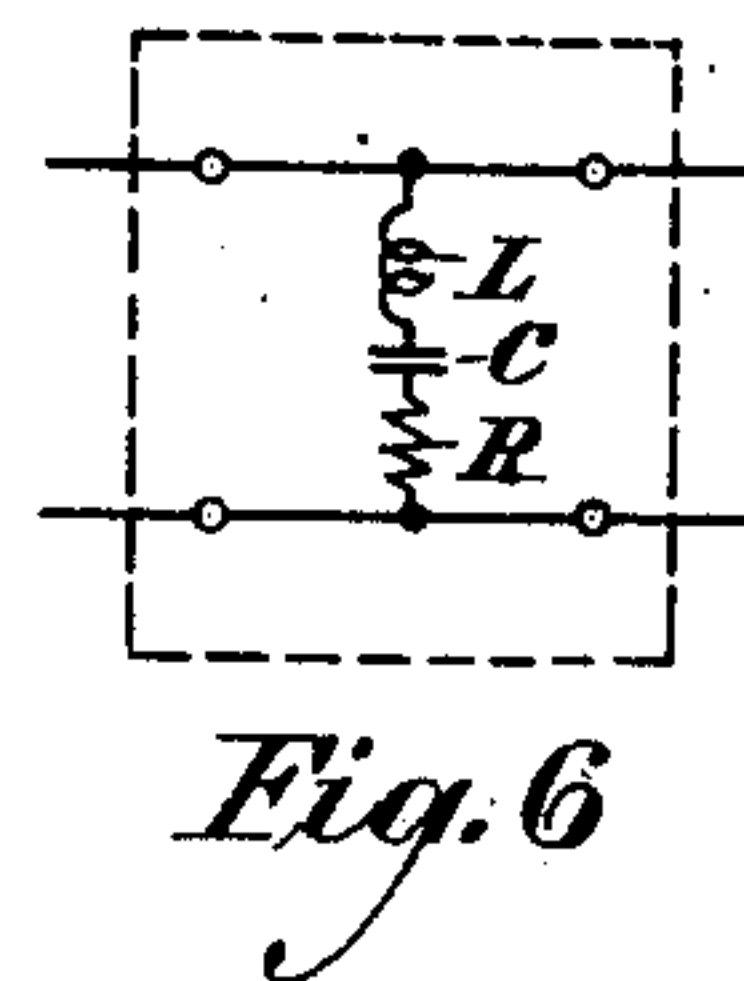
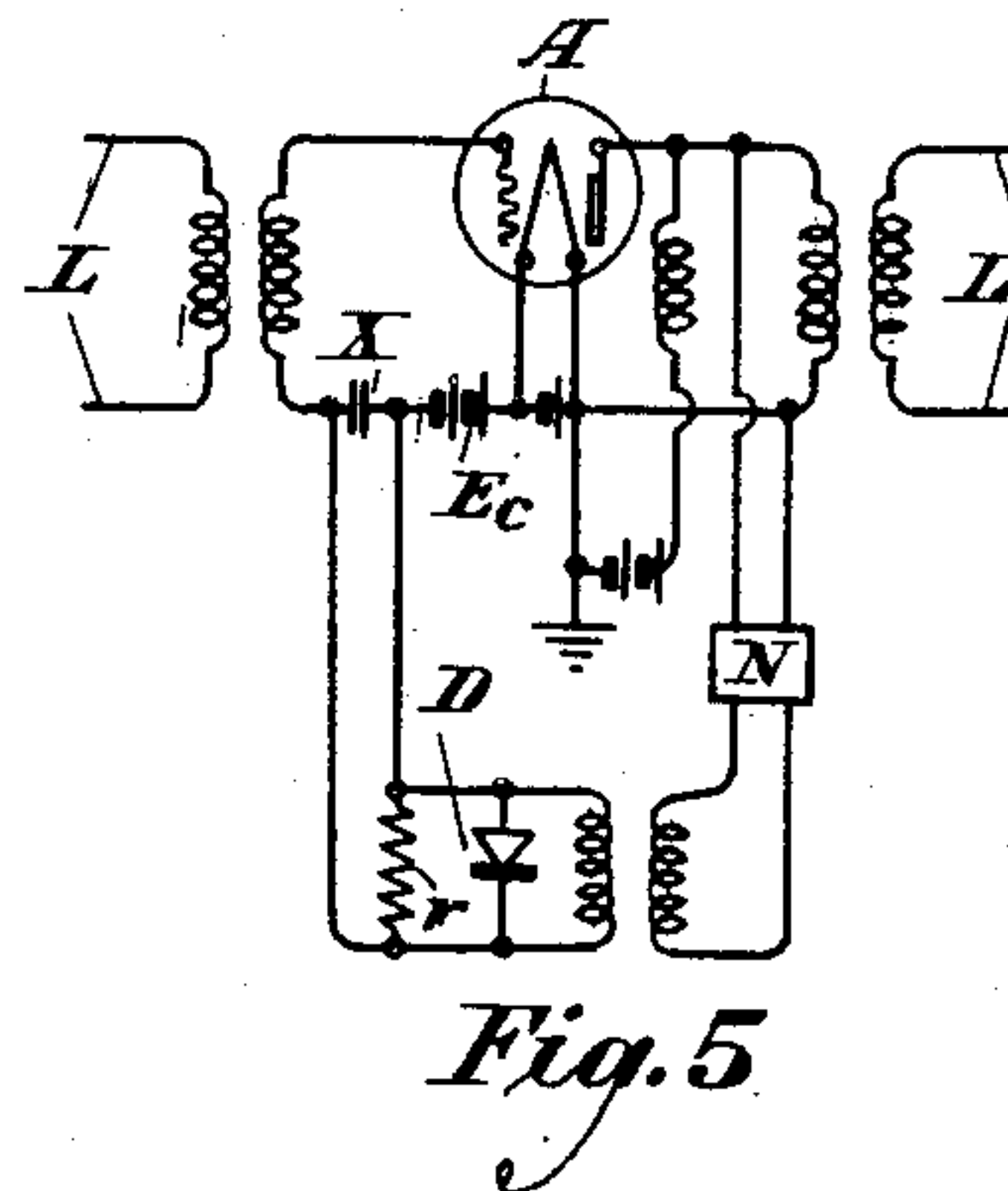
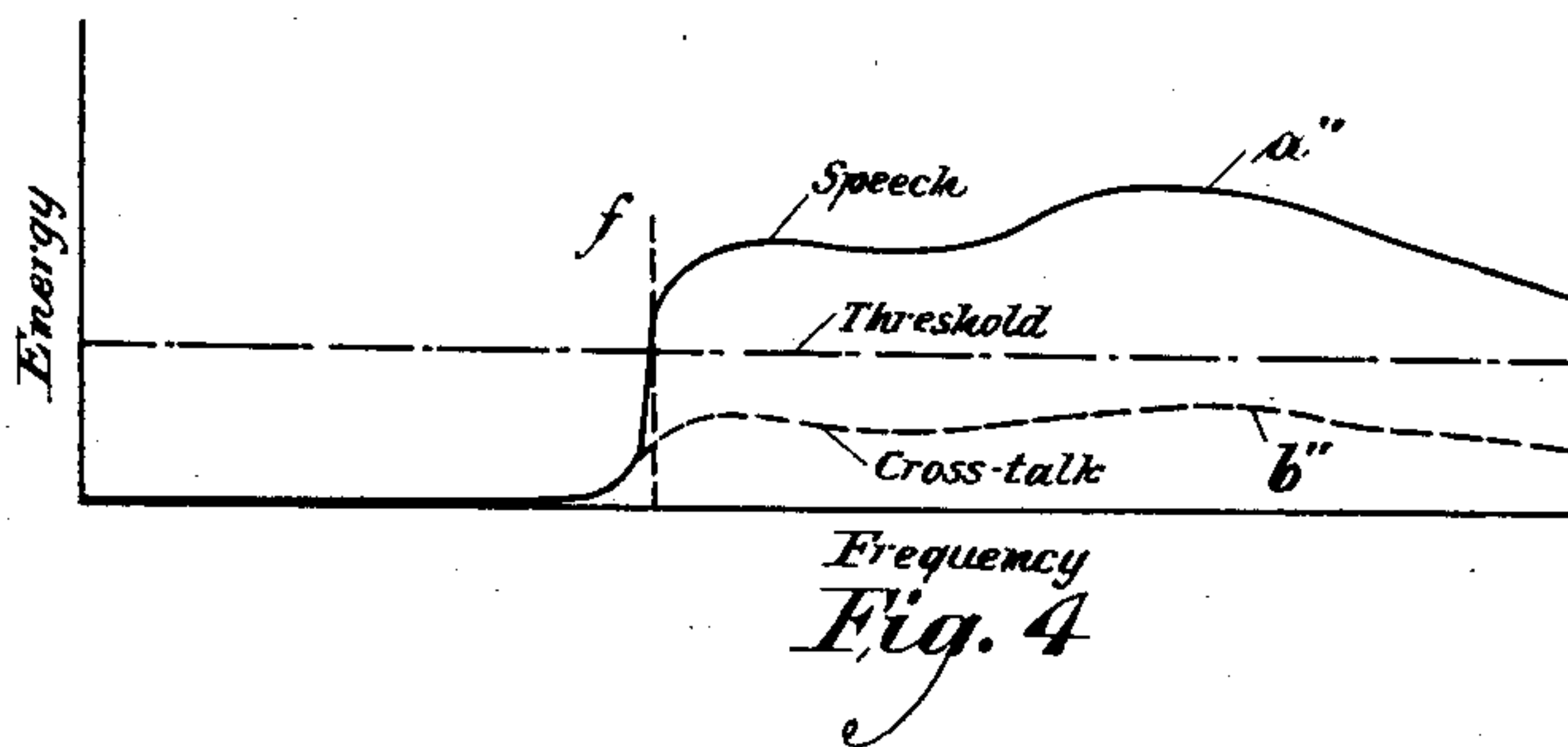
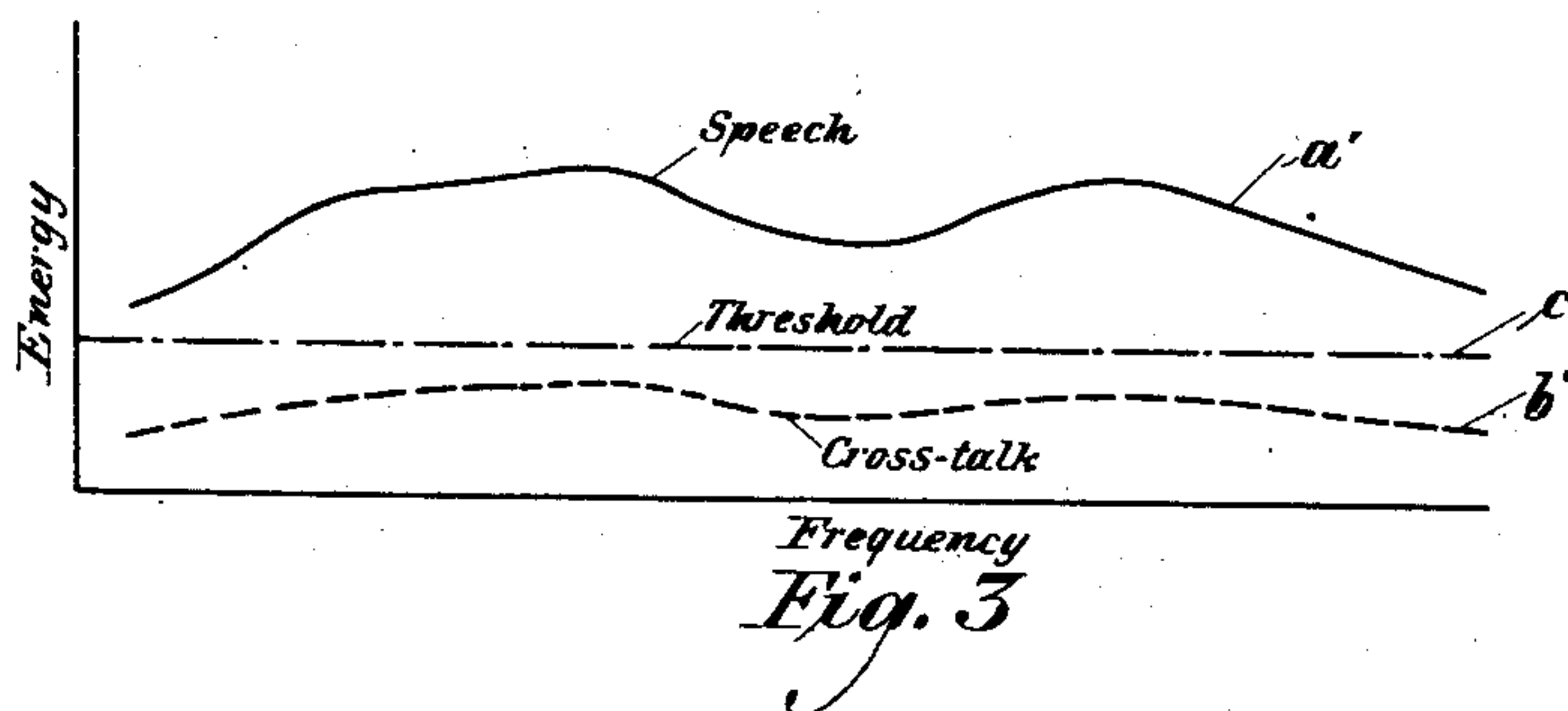
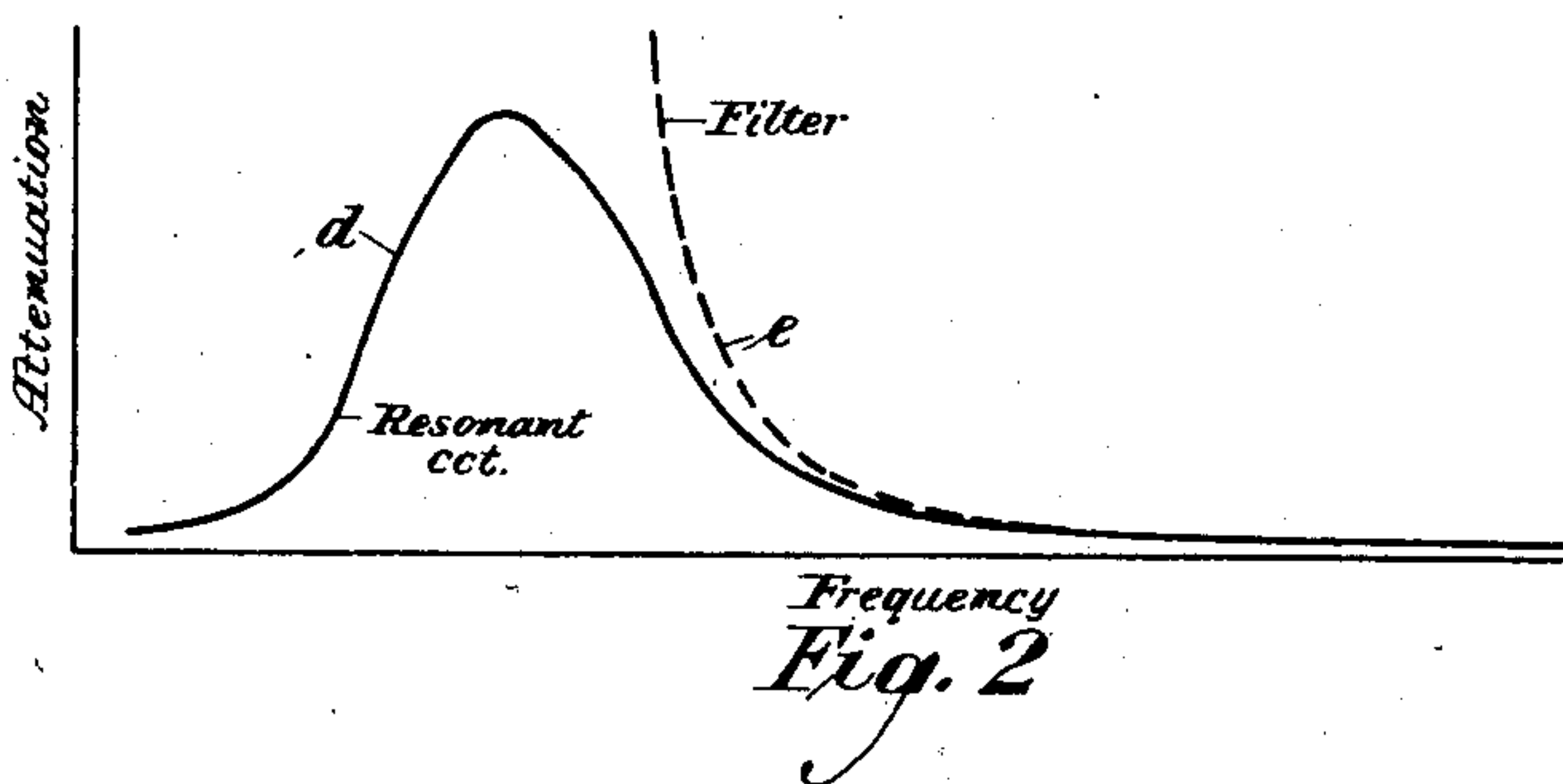
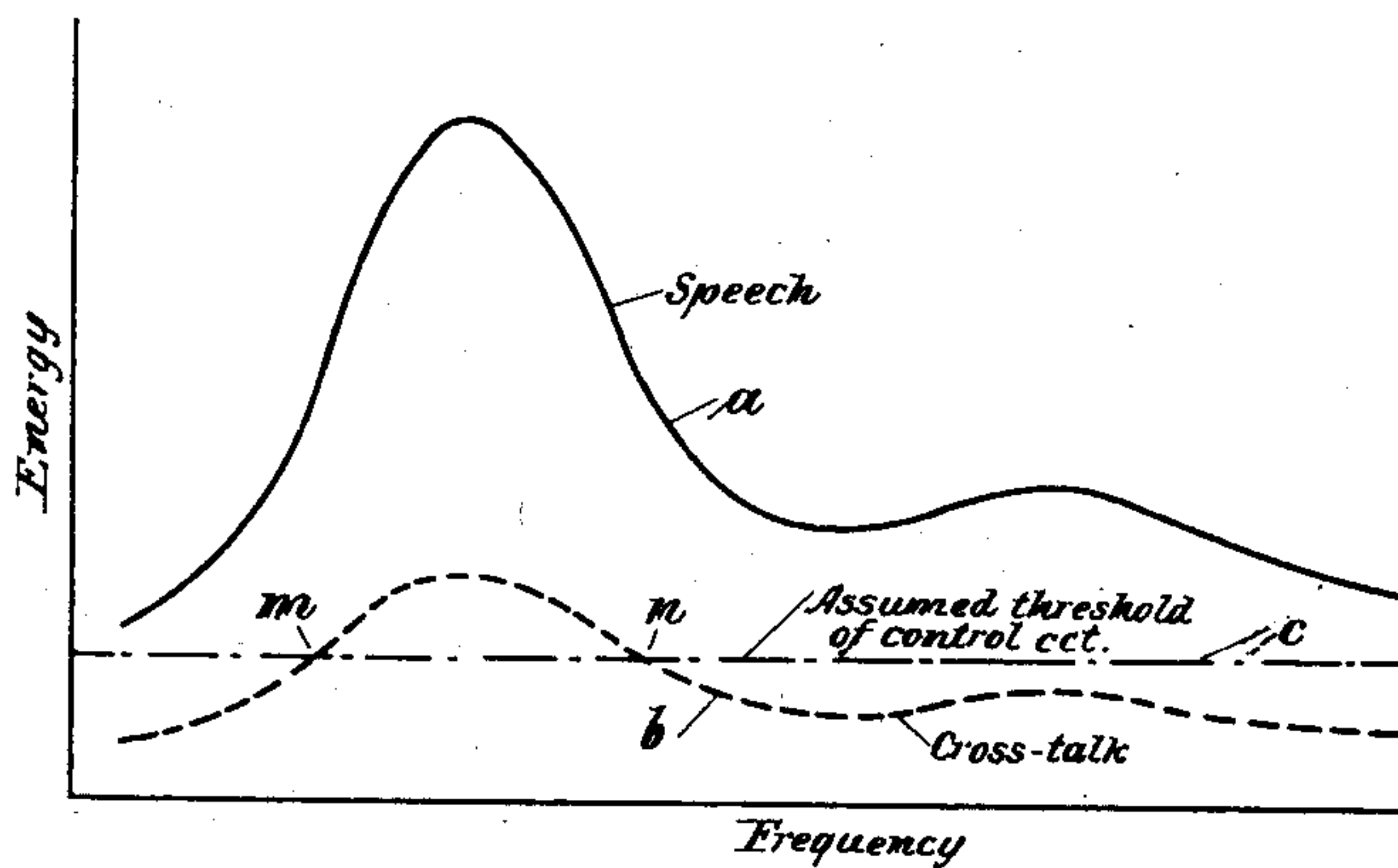
Dec. 9, 1930.

A. CARPE

1,784,178

VOICE CONTROLLED CIRCUITS

Filed Aug. 18, 1928



INVENTOR

A. Carpe

BY

ATTORNEY

UNITED STATES PATENT OFFICE

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

VOICE-CONTROLLED CIRCUITS

Application filed August 18, 1928. Serial No. 300,473.

This invention relates to voice operated devices in which a speech wave is utilized to control the transmission through or operation of a signal circuit.

While the invention is of general application, it is illustrated in connection with an amplifier in which the output circuit is connected back to the input circuit through a control element for the purpose of rendering the amplifier inoperative unless the input energy exceeds a certain threshold value. It is well known that the energy of speech waves varies widely with frequency, the lower frequencies of the voice range, and particularly the vowel sounds, being of relatively large energy, while the higher frequencies, which are more characteristic of consonant sounds, are of relatively small energy. The threshold value of the control circuit must, therefore, be low enough to enable the system to respond to the higher frequency components of small energy.

Where the circuit is subject to cross-talk, however, the lower frequencies involved in the cross-talk wave may have sufficient energy to exceed the threshold value so that a false operation of the control circuit would result. To avoid this it is proposed, in accordance with the present invention, to render the control circuit less responsive at those frequencies whose energy is large than to frequencies whose energy is small. This permits making the threshold value of the control circuit low enough to permit response to the low energy frequencies without responding to the cross-talk frequencies of large energy, the cross-talk frequencies of large energy being ineffective by reason of having been reduced or attenuated in the control circuit before being applied to the sensitive control element. Due to the fact that the frequencies of the voice band which are of the largest energy occur in the lower part of the range, it is desirable in some instances to completely suppress these frequencies from the control circuit by suitable selecting means, in which event the threshold value to which the control element responds may be reduced to a point just above the energy level of the high-

er frequencies encountered in the cross-talk or noise on the system.

The invention may now be more fully understood from the following description when read in connection with the accompanying drawing in which Figures 1, 2, 3 and 4 show curves illustrating the operation of the invention; Fig. 5 illustrates a circuit diagram embodying the invention; while Figs. 6, 7 and 8 illustrate various equalizing devices to be used in connection with the control circuit.

As illustrated in Fig. 5, the transmission circuit L has included therein a vacuum tube amplifier A. In order that the amplifier may be inoperative unless the input energy exceeds a certain threshold value, the output or plate circuit of the amplifier is connected to the input or grid circuit through a control circuit which may, if desired include elements such as rectifying, amplifying and current limiting devices. For practical purposes a rectifying element only will be sufficient, and this element is represented symbolically by the rectifier D. The grid circuit is biased by means of a battery C to such a negative value that normally substantially no plate current can flow, and hence the amplifier is practically inoperative under these conditions. When a voice wave is applied, however, some of the voice energy from the output of the amplifier is rectified by the rectifier D and applied to the grid of the amplifier across the terminals of a condenser X in such a direction as to oppose the potential from the battery C. In the case of a voice wave producing a rectified current of sufficient amplitude the grid will be rendered sufficiently less negative so that it becomes an efficient amplifier.

As has been previously stated, it is well known that the energy of a speech wave varies widely with frequency, the lower frequencies which are most prominent in vowel sounds being of large energy compared with the higher frequencies which are characteristic of consonant sounds. If, therefore, in Fig. 5, the control circuit picks off from the output of the amplifier a fraction of the energy of a train of speech waves with equal efficiency at all frequencies, it is obvious that the control circuit must be made sufficiently sensitive to

operate on the weakest important portions of the controlling signal. In other words, its threshold of operation must be sufficiently low so that the system will respond to the high frequency components of small energy. Under these conditions, however, the control circuit will be much more sensitive than would be necessary to obtain adequate response to those portions of the signal wave which embody different frequencies having greater energy.

Furthermore, in order that the circuit may be immune from false operation due to interference and cross-talk, it is clear that the threshold of operation of the control circuit (which is fixed by the weakest portions of the controlling wave) must be greater than those components of cross-talk or interference which are of largest energy. Now, while the energy represented by the interference may actually be very much smaller at a given frequency than the energy available in the controlling wave at the same frequency, the threshold of the control circuit may be so low as to render it liable to interference because this threshold is determined by the energy available in the controlling circuit at some other frequency. This is particularly true where the interference is produced by speech cross-talk because the energy distribution with frequency of the interference would then be approximately the same as that of the controlling speech wave. This is illustrated by the curves of Fig. 1 in which the curve *a* represents the average distribution of the energy of vocal sounds with frequency, and the curve *b* represents a corresponding average distribution for cross-talk. If the curve *c* may be taken as representing the minimum energy necessary to cause proper response on the part of the amplifier A, or, in other words, if *c* represents the threshold of operation, it will be seen that while this threshold is low enough to respond to all portions of the speech wave represented by the curve *a* without responding to the higher frequency elements of the cross-talk curve *b*, the lower frequency elements of the cross-talk curve are of sufficient energy to exceed the threshold value and thereby cause false operation of the amplifier A. This is shown by those portions of the cross-talk curve between *m* and *n*. From these curves of Fig. 1 it is evident that if we include in the control circuit a network N so designed as to discriminate against those frequencies which appear in the hump of the curve *a*, the amplitude of the components of the cross-talk represented between *m* and *n* will also be reduced so that they will fall below the assumed threshold of operation.

The ideal condition would be to have the network N so designed that voice frequency components applied to it with varying energies, represented by the curve *a*, would, after transmission through the network, be

reduced to a common amplitude higher than that represented by the curve *c*. While this might be done by designing a sufficiently complicated network N, in practice a sufficient equalization may be obtained by means of a tuned circuit which is resonant at the peak frequency of the hump of the curve *a* of Fig. 1, and which has sufficient damping so as to reduce the curve in the vicinity of the peak to approximately the same level. The network N may, therefore, assume the form illustrated in Fig. 6, in which a tuned circuit comprising inductance L, capacity C and resistance R is shunted across the line conductors so as to attenuate the resonant frequency and the frequencies in the neighborhood of the frequency to which the tuned circuit is resonant. The attenuation of the network N as thus designed may then vary with frequency as represented by the curve *d* of Fig. 2, in which case the speech curve represented at *a* in Fig. 1, after passing through the network N, may assume somewhat the form of the curve represented at *a'* in Fig. 3. Here, it will be observed that the large hump in the low frequency range has disappeared, and the curve representing the energy of speech exhibits only two small humps, with the energy over the entire range departing but little from the average value. All parts of the curve *a'*, it will be observed, are above curve *c* representing the threshold of operation. The cross-talk curve will be somewhat as represented at *b'*, since the cross-talk in the range *m*, *n* of Fig. 1 will be attenuated in proportion to the attenuation of normal speech. All parts of the cross-talk wave *b'* of Fig. 3 are below the threshold of operation of the system, and hence no false operation will occur in response to cross-talk.

Instead of using a shunt resonant circuit as illustrated in Fig. 6, the network N may comprise an anti-resonant circuit, as illustrated in Fig. 7, in which a loop comprising inductance L' and capacity C' shunted by resistance R' is connected in series with the line conductors. Such a network may have the same attenuation characteristics as illustrated at *d* in Fig. 2 so that the system will have the characteristics illustrated by the curves of Fig. 3.

It will be noted from the curves *a* and *b* of Fig. 1 that those speech frequencies which cause false operation are the lower frequencies of the voice range represented largely by vowel sounds. It may, therefore, be desirable in some instances to actually cause a complete suppression of these lower frequencies in the control circuit, especially as the fundamental vowel frequencies are always accompanied by harmonics of smaller energy in the higher portions of the voice range, so that even in the case of pure vowel sounds there will be some unsuppressed frequencies to operate the control circuit. In this case

the network may assume the form of a filter of the Campbell type, for example, a high pass filter such as shown in Fig. 8. Such a filter functions to pass frequencies above a lower limit and to suppress all frequencies below this limit. The attenuation curve of the filter of Fig. 8 may assume the form shown at *e* of Fig. 2, in which case the energy of the range of frequencies illustrated by the curve *a* of Fig. 1 would assume the general form illustrated at *a''* of Fig. 4, after passing through the filter. Consequently, frequencies below the cut-off frequency *f* cannot operate the system. The frequencies above the cut-off point, however, will have energy greater than the threshold value, as will be clear from Fig. 4. The lower frequencies of the cross-talk will also be suppressed so that the cross-talk curve corresponding to *b* of Fig. 1 will assume the form *b''* of Fig. 4. This curve, where unsuppressed, is at all points below the threshold value, so that no false operation will occur.

The use of a filter, with consequent suppression of the lower frequencies as illustrated in the curves of Fig. 4, brings about a further desirable result. In the circuit as illustrated in Fig. 5, there is a feed-back connection from the output to the input of the amplifier which would cause a singing condition to be set up if the entire loop circuit were responsive to any common frequency. To prevent this condition, the control circuit is connected to the input of the amplifier through a combination comprising a capacity *X* shunted by a resistance *r*. When energy is applied to the control circuit from the output of the amplifier it must build up in the capacity-resistance combination to a certain minimum value before singing can result. This minimum value must be such that the resultant potential on the grid will cause an amplified wave in the plate circuit at least equal to the original plate wave which built up the energy in the resistance-capacity combination. The resistance-capacity combination should, therefore, have a time constant such as to prevent the building-up of this energy to the minimum value within the time of a cycle of the lowest frequency which is to be transmitted. If the input to the control circuit is equally responsive to the entire voice range, the time constant of the capacity-resistance combination must be large in order to prevent singing at the lower frequencies, and hence the action of the control circuit will be sluggish. The neutralizing potential upon the grid is built up as slowly as the wave tending to produce singing. Where, however, the control circuit is made relatively unresponsive to low frequencies, it is possible to decrease the time constant of the resistance-capacity combination since the circuit is only responsive to the higher frequencies and the resist-

ance-capacity combination need be only sufficiently sluggish to prevent singing at such higher frequencies. By rendering the control circuit selective by means of a filter, so that low frequencies do not exceed the threshold value of the control circuit, the distortion of the waves transmitted through the amplifier, resulting from the sluggishness of the control action, will be correspondingly reduced.

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 element, a voice responsive control circuit for determining the effectiveness of said transmission element in response to voice frequency components of predetermined magnitude, and means associated with said control circuit to discriminate against those frequencies of an applied voice wave which are in a range of large energy, whereby corresponding components of induced cross-talk will be reduced to a magnitude smaller than applied voice frequencies in a range of small energy.
2. In a transmission system, a transmission element, a voice responsive control circuit for determining the effectiveness of said transmission element in response to voice frequency components of predetermined magnitude, and means associated with said control circuit to reduce those frequency components of an applied voice wave which are in a range of large energy to a value not greater than that of applied voice frequency components in a range of small energy, whereby relatively large energy components of induced cross-talk will be reduced to a magnitude smaller than applied voice frequencies of small energy.
3. In a transmission system, a transmission element, a voice responsive control circuit for determining the effectiveness of said transmission element in response to voice frequency components of predetermined magnitude, and means associated with said control circuit to substantially suppress from an applied voice wave such of its frequency components as lie in a range of large energy, whereby corresponding frequency components of induced cross-talk will be suppressed.
4. In a transmission system, a transmission element, a voice responsive control circuit for determining the effectiveness of said transmission element in response to voice frequency components of predetermined magnitude, means associated with said control circuit to substantially suppress from an applied voice wave such of its frequency

components as lie in a range of large energy, whereby corresponding frequency components of induced cross-talk will be suppressed, and means for preventing singing of the transmission element and control circuit at unsuppressed frequencies.

5. In a transmission system, a transmission element which is normally substantially inoperative to transmit, a voice responsive control circuit for rendering said transmission element operative in response to voice frequency components of small energy of predetermined minimum value, and means associated with said control circuit to discriminate against those frequencies of an applied voice wave which are in a range of large energy, whereby corresponding components of induced cross-talk will be reduced to a magnitude smaller than applied voice frequencies in a range of small energy.

6. In a transmission system, a transmission element which is normally substantially inoperative to transmit, a voice responsive control circuit for rendering said transmission element operative in response to voice frequency components of small energy of predetermined minimum value, and means associated with said control circuit to reduce those frequency components of an applied voice wave which are in a range of large energy to a value not greater than that of applied voice frequency components in a range of small energy, whereby relatively large energy components of induced cross-talk will be reduced to a magnitude smaller than applied voice frequencies of small energy.

7. In a transmission system, a transmission element which is normally substantially inoperative to transmit, a voice responsive control circuit for rendering said transmission element operative in response to voice frequency components of small energy of predetermined minimum value, and means associated with said control circuit to substantially suppress from an applied voice wave such of its frequency components as lie in a range of large energy, whereby corresponding frequency components of induced cross-talk will be suppressed.

8. In a transmission system, a transmission element which is normally substantially inoperative to transmit, a voice responsive control circuit for rendering said transmission element operative in response to voice frequency components of small energy of predetermined minimum value, means associated with said control circuit to substantially suppress from an applied voice wave such of its frequency components as lie in a range of large energy, whereby corresponding frequency components of induced cross-talk will be suppressed, and means for preventing singing of the transmission element and control circuit at unsuppressed frequencies.

9. In a transmission system, a transmission circuit including an amplifier normally substantially inoperative to amplify, a voice responsive control circuit including means responsive to applied voice frequency components of small energy greater than a predetermined minimum value to render said amplifier operative to amplify efficiently, and means associated with said control circuit to discriminate against those frequencies of an applied voice wave which are in a range of large energy, whereby corresponding components of induced cross-talk will be reduced to a magnitude smaller than applied voice frequencies in a range of small energy.

10. In a transmission system, a transmission circuit including an amplifier normally substantially inoperative to amplify, a voice responsive control circuit including means responsive to applied voice frequency components of small energy greater than a predetermined minimum value to render said amplifier operative to amplify efficiently, and means associated with said control circuit to reduce frequency components of an applied voice wave which are in a range of large energy to a value not greater than that of applied voice frequency components in a range of small energy, whereby relatively large energy components of induced cross-talk will be reduced to a magnitude smaller than applied voice frequencies of small energy.

11. In a transmission system, a transmission circuit including an amplifier normally substantially inoperative to amplify, a voice responsive control circuit including means responsive to applied voice frequency components of small energy greater than a predetermined minimum value to render said amplifier operative to amplify efficiently, and means associated with said control circuit to substantially suppress from an applied voice wave such of its frequency components as lie in a range of large energy, whereby corresponding frequency components of induced cross-talk will be suppressed.

12. In a transmission system, a transmission circuit including an amplifier normally substantially inoperative to amplify, a voice responsive control circuit including means responsive to applied voice frequency components of small energy greater than a predetermined minimum value to render said amplifier operative to amplify efficiently, means associated with said control circuit to substantially suppress from an applied voice wave such of its frequency components as lie in a range of large energy, whereby corresponding frequency components of induced cross-talk will be suppressed, and means for preventing singing of the amplifier over the control circuit at unsuppressed frequencies.

13. In a transmission system, a transmission circuit including a vacuum tube having its grid normally biased to operate on an ineffective part of its characteristic curve, a voice responsive control circuit, means in said control circuit responsive to applied voice frequencies of small energy but greater than a predetermined minimum value to produce a rectified potential, means to apply said potential to the grid of said vacuum tube in such direction as to shift the operation to an effective part of the characteristic of the tube, and means associated with said control circuit to discriminate against those frequencies of an applied voice wave which are in a range of large energy, whereby corresponding components of induced cross-talk will be reduced to a magnitude smaller than applied voice frequencies in a range of small energy.

14. In a transmission system, a transmission circuit including a vacuum tube having its grid normally biased to operate on an ineffective part of its characteristic curve, a voice responsive control circuit, means in said control circuit responsive to applied voice frequencies of small energy but greater than a predetermined minimum value to produce a rectified potential, means to apply said potential to the grid of said vacuum tube in such direction as to shift the operation to an effective part of the characteristic of the tube, and means associated with said control circuit to reduce those frequency components of an applied voice wave which are in a range of large energy to a value not greater than that of applied voice frequency components in a range of small energy, whereby relatively large energy components of induced cross-talk will be reduced to a magnitude smaller than applied voice frequencies of small energy.

15. In a transmission system, a transmission circuit including a vacuum tube having its grid normally biased to operate on an ineffective part of its characteristic curve, a voice responsive control circuit, means in said control circuit responsive to applied voice frequencies of small energy but greater than a predetermined minimum value to produce a rectified potential, means to apply said potential to the grid of said vacuum tube in such direction as to shift the operation to an effective part of the characteristic of the tube, and means associated with said control circuit to substantially suppress from an applied voice wave such of its frequency components as lie in a range of large energy, whereby corresponding frequency components of induced cross-talk will be suppressed.

16. In a transmission system, a transmission circuit including a vacuum tube having its grid normally biased to operate on an ineffective part of its characteristic curve, a voice responsive control circuit, means in said

control circuit responsive to applied voice frequencies of small energy but greater than a predetermined minimum value to produce a rectified potential, means to apply said potential to the grid of said vacuum tube in such direction as to shift the operation to an effective part of the characteristic of the tube, means associated with said control circuit to substantially suppress from an applied voice wave such of its frequency components as lie in a range of large energy, whereby corresponding frequency components of induced cross-talk will be suppressed, and means to prevent singing of the vacuum tube over said control circuit at unsuppressed frequencies.

In testimony whereof, I have signed my name to this specification this 17th day of August, 1928.

ALLEN CARPE.

85

90

95

100

105

110

115

120

125

130