Nov. 6, 1928. 1,690,918

J. ZENNECK ET AL

TONE RECEIVER FOR UNDAMPED OSCILLATIONS

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Fig. 1.

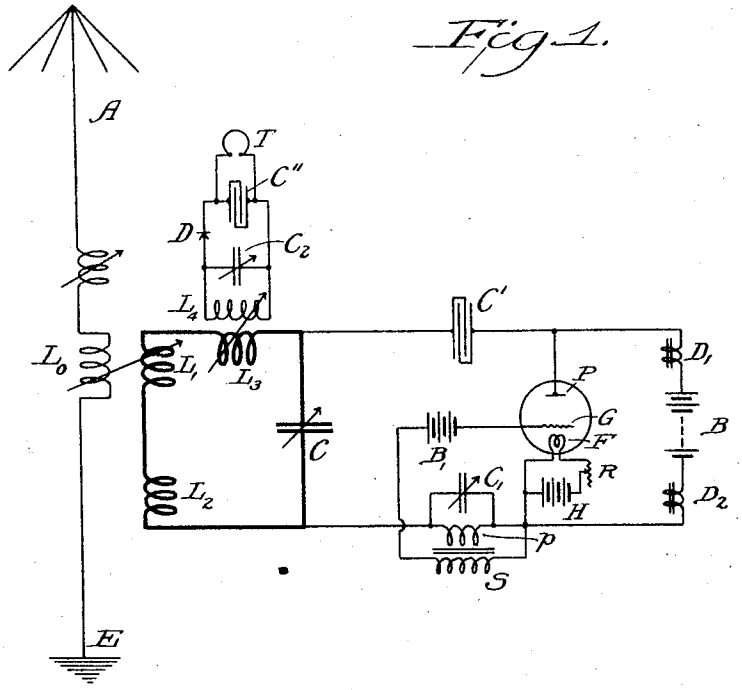

Fig. 2.

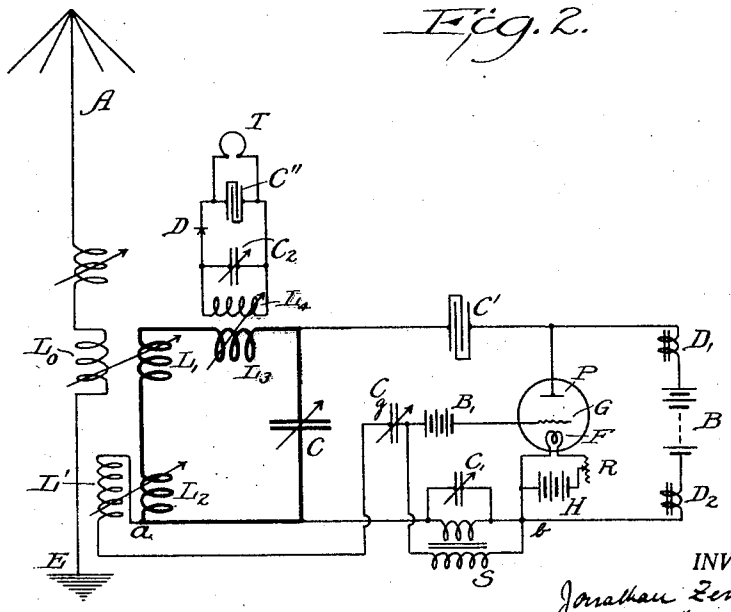

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Fig. 3

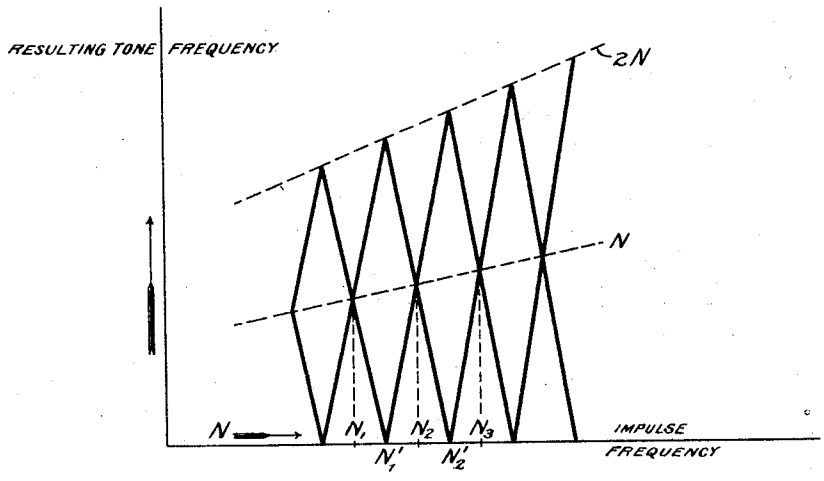
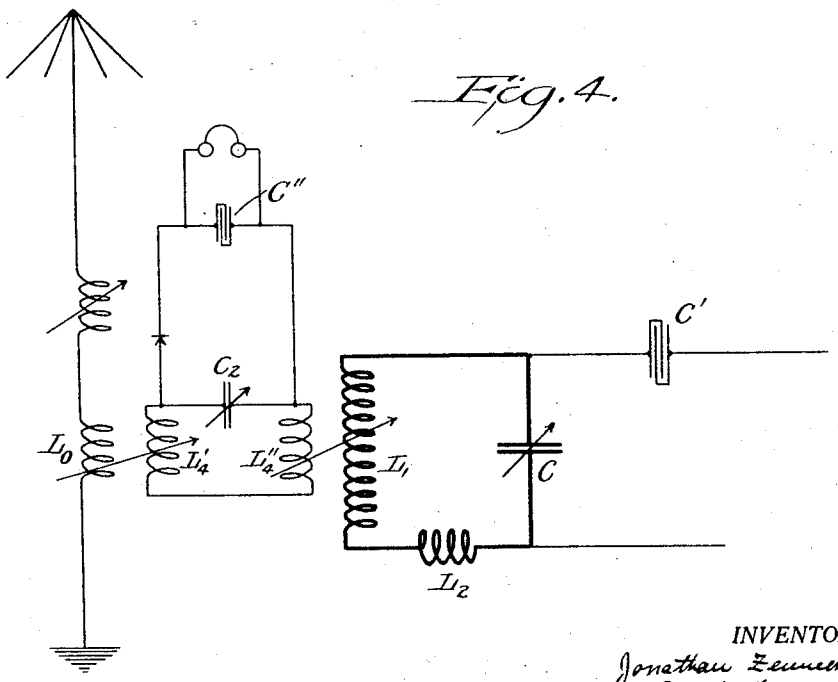


Fig. 4.



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UNITED STATES PATENT OFFICE.

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TONE RECEIVER FOR UNDAMPED OSCILLATIONS.

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Our invention relates to the reception of undamped waves such as are use in radio telegraphy, and it is the particular purpose of this invention to receive such waves or signals which are sent by means of such waves, in the form of audible tones in an aural receiver, for instance a telephone.

The fundamental idea on which our invention is based consists in producing in the system by which the arriving undamped oscillations are received, damped oscillations at regular intervals and a suitable number of times per second, which damped oscillations are superimposed upon the received undamped oscillations. These damped oscillations may be produced in the form of impulses imparted to an oscillatory circuit which is part of the receiving system, by any suitable means known in the art. The oscillations resulting from such a superimposition of aforesaid impulses upon the received undamped oscillations are oscillations of a periodically varying amplitude. If now a detector circuit is suitably coupled with the circuit carrying these periodically varying oscillations, one or several tones are obtained which correspond with the periodical variations of the amplitude of the resulting oscillations.

The amplitude of the above-mentioned resulting oscillations depends upon the condition of the phase of the received undamped oscillations, at which the impulse excited oscillations start. Thus a regular periodical variation of this amplitude can only occur if the difference between the individual intervals within which the impulse occurs, is very small compared with the high frequency period of the received undamped oscillations.

If this condition is fulfilled generally a double tone will be received in the detector circuit, both of which tones are of a frequency which is different from the frequency at which the impulses occur. Only at a very definite relation between the high frequency of the received oscillations and the impulse frequency, the two resulting tone frequencies will coincide so that only one tone will be heard in the telephone connected into the detector circuit.

It would be very difficult to produce impulses of such a regularity as is required for the production of a musical tone in the telephone by mechanical means, i. e. by mechanical interrupters. We have found, however, that thermionic relays are very well suited for producing impulses of a desired low frequency which are adapted to impart the necessary impulses to a local high frequency circuit at absolutely regular intervals. Of course, the degree of regularity depends upon keeping the plate voltage and the filament current constant.

The circuit arrangements which may be used for locally producing such a low frequency for these impulse purposes may vary considerably since at the present day quite a number of different circuit connections for thermionic relays are known in the art by which such relays are caused to produce continuous oscillations of any desired frequency.

In the accompanying drawings we have illustrated several circuit arrangements in which the idea involved in our invention may be reduced to practice without thereby limiting the practical form of our invention to these modifications shown, since it is obvious to any one skilled in the art that similar results may be obtained by varying the individual details of the elements of which the circuit arrangement is composed.

Referring to these drawings:—

Figures 1, 2 and 4 represent modified forms of circuit diagrams by which the effect referred to hereinbefore may be obtained; and

Figure 3 represents a curve diagram which will be explained hereinafter.

Referring now in detail to Figure 1, A represents an antenna by which for example the undamped waves may be received. The circuit C, L_1, L_2, L_3 represents a local high frequency oscillatory circuit in which it is proposed, according to the present invention, to produce damped oscillations by regularly occurring impulses. This local oscillating circuit is shown in the diagram by heavy lines and it is coupled at L_1 with the antenna circuit by means of the inductance L_0 contained in the antenna circuit, such that by this coupling the received undamped oscillations are transferred into the local oscillating circuit.

The low frequency circuit in which the low frequency impulses are produced is the circuit C_1, p. These low frequency impulses in this circuit are due to the coupling p, S with the grid circuit of a thermionic relay which consists of the filament F, and grid

G and the plate P all arranged in the conventional manner known in the present day art. The relay circuits consist of the plate circuit containing the plate P, the battery B and the filament F and besides a suitable number of choking coils D_1, D_2, and of the grid circuit including the grid G, a grid potential battery E_1, transformer coil S and the filament F. The filament is heated by means of the heating battery H whose current is controlled by means of the rheostat R. In the modification shown as an example the low frequency impulse circuit is conductively coupled with the local high frequency circuit by the connection with the circuit at either side of condenser C.

The detector circuit is represented by the circuit C_2, L_4 and coupled at L_4 with the inductance L_3 of the local high frequency circuit. The dectector D is connected to the detector circuit in the conventional manner known in the art and includes in its circuit connections a blocking condenser C'' and a telephone T. The detector D is illustrated only by the conventional symbol for detectors and may represent any suitable detector such as for instance an electrolytic detector, a crystal detector, an oscillating or non-oscillating audion or the like, all of which expedients are well known in the art.

If now for instance in the arrangement according to Figure 1 the condensers C and C_2 are adjusted such that the tone intensity in the telephone is quite satisfactory and if now the low impulse frequency is gradually increased for instance by varying the condenser C_1, the following phenomenon occurs which is represented in the curve diagram Figure 3: at a certain low impulse frequency N_1 a single tone is produced whose frequency is equal to the impulse frequency N. If now the low impulse frequency is gradually further increased, two tones will be produced, the pitch of one of which becomes higher and higher whereas the pitch of the other becomes lower and lower and finally the latter tone becomes inaudible. From a certain value of the gradually increased impulse frequency, namely the value N_1' in Figure 3 the pitch of the higher tone commences gradually to decrease, whereas the pitch of the lower tone again increases until both tones again coincide at a value N_2. On further increasing the impulse frequency the same phenomenon occurs, whereby the maximum pitch of the higher tone becomes higher with each progressing cycle as is indicated by the dotted line 2N.

The pitch of the tone is practically independent of the adjustment of the condenser C and thus of the frequency of the local high frequency circuit shown in heavy lines. A variation of the condenser C either does not vary the tone at all or to only a very slight and immaterial extent. In case it should slightly vary it can easily be proven that such a slight variation of the tone is caused by the fact that by varying the capacity of condenser C a slight influence is exerted upon the frequency of the impulse frequency circuit. On the other hand, by variation of condenser C the tone intensity of the resulting tone is varied to a considerable extent. This intensity is a maximum for a certain capacity value of condenser C and decreases, at the variation of condenser C in either direction from this resonance adjustment, in the form of a resonance curve.

The phenomenon illustrated in the curve diagram Figure 3 might be explained as follows:

The fundamental impulse frequency produced in the low frequency circuit has higher harmonics, some of which have frequencies in the vicinity of the received high frequencies. These harmonics are transferred into the local high frequency oscillation circuit, where they form beats with the received frequency, which beats are audible in the telephone. The double tone is produced by beats with the two harmonics adjacent to the received frequency. If the received frequency is located exactly in the middle between two adjacent harmonics, the two beat frequencies produced are identical and thus only one tone will be audible. This is also the case if the received frequency and one of the harmonics are identical in frequency. If on the other hand the received frequency is not located in the middle, the beat frequency produced with one of the harmonics will be different from the beat frequency produced with the other harmonic and a double tone will result.

Figure 2 is distinguished from Figure 1 only by the feature that in Figure 2 not only the impulse frequency circuit C_1, p, but also the local high frequency circuit C, L_1, L_2, L_3 is coupled with the grid circuit of the thermionic relay by means of a coupling coil L'. The result of such an additional coupling is that in the local high frequency circuit, damped high frequency oscillations are produced with a varying amplitude even if no undamped high frequency oscillations arrive at the antenna. The advantage of such an arrangement is that the tone intensity in the telephone becomes by far greater. This arrangement, however, has the disadvantage that the adjustment of the different variable elements in order to produce a good tone is very sensitive and critical. The probable reason for this sensitiveness is that disturbing beat tones may be produced.

In both modifications Figures 1 and 2 it is essential for the production of a good tone and a good efficiency to correctly adjust the heating current and the plate voltage of the thermionic relay.

For obtaining the results described hereinbefore with reference to Figures 1 and 2 it is not necessary as shown in these figures that the undamped oscillations in the antenna are first transmitted by suitable coupling to the local high frequency circuit C, L_1, L_2, L_3 and that then the resulting oscillations of varying amplitude are transferred from the local high frequency circuit to the detector circuit. As is shown for instance in Figure 4, the antenna and the local high frequency circuit may each be individually coupled with the detector circuit by means of the inductances L_4' and L_4'' without changing the result described. The characteristic features by which our invention is distinguished over devices heretofore used for receiving undamped oscillations in the form of audible tones are as follows:—

Firstly the tone which is produced in the receiving telephone is in its frequency different from the frequency of the low frequency impulse circuit C_1, p, except in the particular cases described hereinbefore with reference to Figure 3. Our arrangement is thus clearly distinguished from the arrangements involving so-called tone superimposition known to the present day art in which a local undamped low frequency is superimposed directly upon the received undamped high frequency, which arrangement is shown and described for instance in U. S. patent of Alexander Meissner No. 1,170,552.

Secondly the harmonics produced in the local high frequency circuit C_1, L_1, L_2, L_3 are produced by a local low frequency source and permit the convenient reception with two tones, whereas the ordinary heterodyne method with its single tone renders it often difficult to hold the transmitting station in the receiving telephone.

We claim:—

In an arrangement for receiving and detecting undamped high frequency oscillations, the combination of a receiving circuit for receiving said undamped high frequency oscillations, a local high frequency oscillating circuit associated therewith, and a local low frequency impulse generator circuit coupled with said local high frequency oscillating circuit, and a detector circuit suitably connected to receive the resulting oscillations produced in said local high frequency oscillating circuit and including an aural receiver for producing audible tones from the received high frequency current and the adjacent harmonics of the superimposed low frequency current.

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