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L. DE FOREST
RADIO RECEIVING SYSTEM

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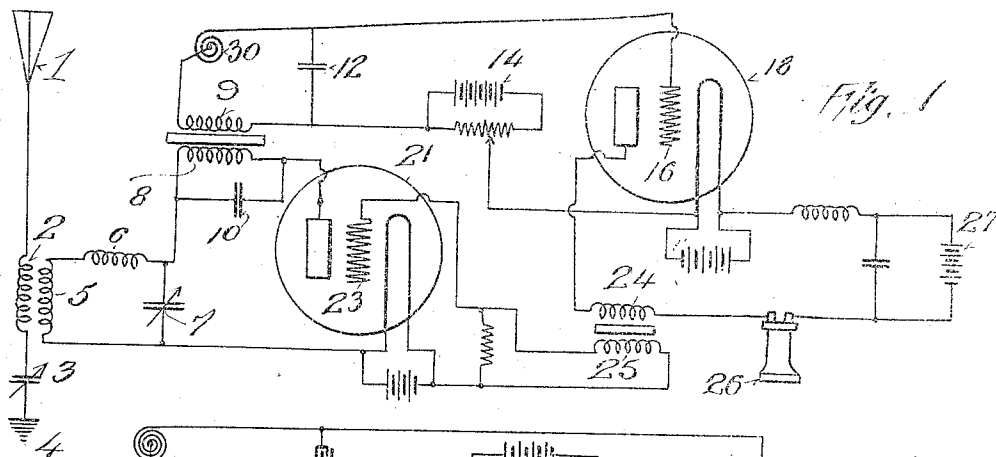


Fig. 1

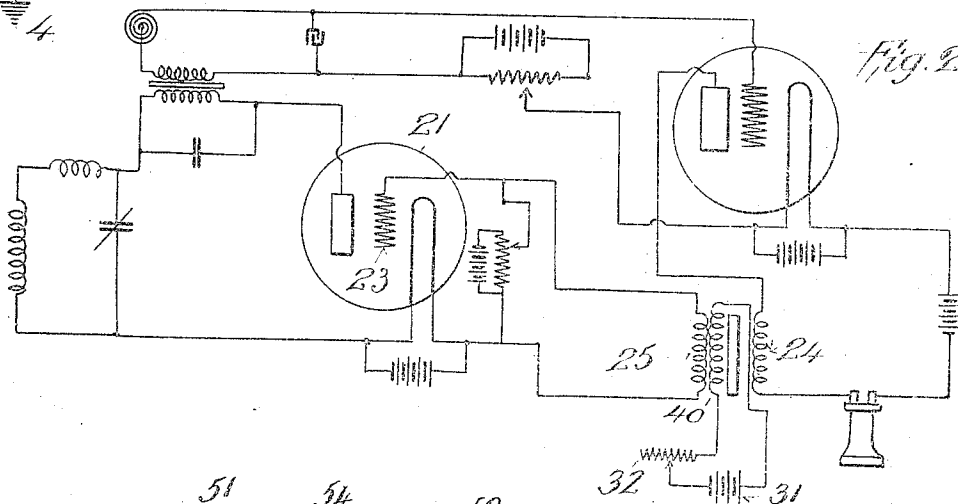


Fig. 2

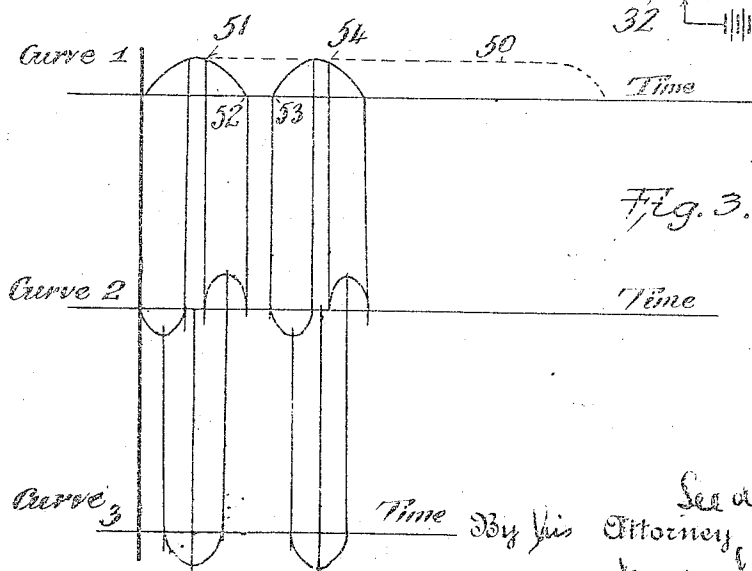


Fig. 3.

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UNITED STATES PATENT OFFICE.

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RADIO RECEIVING SYSTEM.

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To all whom it may concern:

Be it known that I, LEE DE FOREST, a citizen of the United States, residing at New York, in the county and State of New York, have made a certain new and useful Invention in Radio Receiving Systems, of which the following is a specification.

This invention relates to radio receiving systems.

The object of the invention is to provide a radio receiving system which is simple and efficient in operation.

A further object of the invention is to provide a radio system wherein the signals are received in the telephone receivers as clear notes.

A further object of the invention is to obtain in telephone receivers a response to undamped wave train signals of constant amplitude received through the antennae system at the receiving station, the said response being in the form of a musical note, without the intermediary of a tikker, tone wheel, or mechanical interrupter of any kind, and, further, without using the principle of heterodyne or beat note reception which requires a local source of oscillations at the receiving station.

Other objects of the invention will appear more fully hereinafter.

My invention consists substantially in the circuit arrangement employed in accordance with my invention.

Referring to the drawings:—

Fig. 1 shows a circuit arrangement embodying my invention;

Fig. 2 shows a slightly modified circuit arrangement;

Fig. 3 is a diagrammatic illustration representing the control effected in accordance with my invention on the signal currents.

The same part is designated by the same reference character wherever it appears.

It is among the special purposes of my present invention to obtain at a receiving station the benefits incident to the reception of signals by the heterodyne or beat note phenomena or by the use of mechanical interrupters or the like, without the disadvantages incident thereto, namely, in the first instance, of the requirement of a local source of oscillation, and, in the second instance, of mechanical means and apparatus incident thereto. In accordance with my invention, I cause the incoming undamped

wave train of the signal to produce electrical operations which automatically act to periodically interrupt or, at least, greatly reduce the amplitude of the said undamped wave train; and at a rate or periodicity of interruption or fluctuation of amplitude which can be varied within suitable limits by the receiving operator. One arrangement of circuits for producing the desired operation above outlined is shown in Figure 1, wherein 1, 2, 3, and 4 illustrate the usual typical receiving antennae system comprising the aerial, primary inductance, series variable condenser and earth connection respectively. The secondary system of the receiver circuit comprises, in the form shown, the coil 5 of the radio frequency transformer, preferably loosely coupled to the primary of the transformer 2, and the loading coil 6 and variable condenser 7 in series therewith. This tuned secondary system is connected to the detector which, as illustrated, is an audion or three electrode device, one terminal of the circuit being connected to the filament electrode of the audion and the other terminal of the plate electrode of the audion through the primary winding 8 of an audio frequency transformer, preferably with an iron core, as illustrated. Across this winding 8 is connected a condenser 10 of a capacity designed to by-pass the radio frequency currents from the receiving secondary circuit but not sufficiently large to needlessly shunt the audio frequency currents in the coil 8. Connected as shown, it will be seen that the audion 21 is merely acting as a rectifier of the received high frequency currents, which rectification action for two electrode devices has long been known as the Edison effect. The third electrode or grid of the audion comes into operation only in connection with the audio frequency currents delivered thereto from the audio frequency amplifying audion 18 in a manner and for a purpose which will be more fully hereinafter set forth.

In the operation of the circuits and devices so far described, the reception of a signal comprised of one long undamped wave train would ordinarily set up in the circuit connecting the filament and plate electrode of the audion 21 a direct current. On account of the presence in the tuned secondary circuit of the loading coil 6 a relatively long period of current rise exists be-

tween the time of beginning the signal and the time when the direct current in the secondary circuit attains a constant maximum amplitude. The form of circuit curve which would be thus obtained in the secondary circuit is shown in curve 1 of Fig. 3, namely, a relatively gradual rise to horizontal line of maximum amplitude, indicated by the dotted line 50. This period of rise can be made short or long according to the degree of stiffness of the secondary circuit and its looseness of coupling to the primary circuit. This change of current from zero to maximum in the primary winding of the audio frequency transformer 8 induces a momentary pulse of current in the secondary winding 9 thereof, as illustrated in curve 2 of Fig. 3. This single pulse of current in the coil 9 is delivered to the grid-filament of the audion amplifier 18, thereby producing a corresponding but greatly amplified current pulse having essentially the same wave form in the plate filament or output circuit of the audion amplifier 18. Energy for this amplified pulse is supplied from the usual B or plate battery 27 connected between the plate and filament of audion 18. This amplified impulse passing through the primary winding 24 of an audio frequency transformer induces in the secondary winding 25 thereof a double pulse indicated in curve 3 of Fig. 3. The secondary winding 25 of the audio frequency transformer is preferably, and as shown, so connected to the grid and filament of audion 21 with the first half of the current pulse in 25 which places a negative charge on the grid 23 as shown at curve 3 of Fig. 3. The negative half of this alternating current impulse will build up on the grid 23 of audion 21 a negative charge of relatively high potential, which will act to more or less completely interrupt the passage between the plate and filament of the audion 21 of the rectified wave train, thereby causing the current curve illustrated as curve 1 of Fig. 3, to fall from 51 to 52, 52 being on or near the zero axis. This current change will in turn induce a positive current pulse in coil 9 and a similar amplified pulse in coil 24 and thus a positive voltage charge upon the grid electrode 23 of audion 21 which, taken in conjunction with the last preceding negative voltage charge on the grid electrode 23, will again permit the rectified current in the circuit 5, 6, 8, to re-establish itself as shown in curve 1 of Fig. 3, through 53 to 54. This increase of current through coil 8 will again cause a pulse in coil 9 and thus another double pulse on grid 23, from which it will be seen that a recurring cycle of rectified current increasing to maximum and automatically cut off to zero or nearly zero will result so long as the incoming wave train continues. A telephone receiver 26 in series with the plate filament circuit and audion

amplifier 18 will, therefore, produce a musical note so long as the wave train is continued. The pitch of this note will depend upon the electrical constants in the audio frequency circuit and also upon the characteristics of the two audion bulbs, the voltage impressed on the grid 16 of audion 18, from the "biasing" or C battery 14 connected in the usual manner. Thus the pitch of the note can be lowered by connecting a fairly large capacity 12 across the terminals of the coil 9.

There is, of course, a time lag between the point where the initial rectified current attains its maximum amplitude at the point 54 of curve 1 of Fig. 3, and the arrival of the resulting negative charge upon the cut-off grid 23 of audion 21; i. e., between the extent of maximum current amplitude and the final cut-off or minimum current flow at 52 of curve 1, Fig. 3. It will also be apparent that there is also a time lag between this point of minimum current and the beginning of the next successive increase of current; i. e., between the point 52 and 53. The duration of these time lags, as well as the shapes of the current curves at the beginning and end of impulse, and therefore the exact timbre or sound quality of the note heard in telephone receiver 26, depends upon the electrical constants of the circuit, the amount of iron in the cores of the transformers 8, 9, and 24, 25, etc.

The method herein illustrated of obtaining from a continuous received wave train a musical note in the telephone receiver is usually independent of the radio tuning of transmitter and receiver. This fact is a decided advantage because in heterodyne receiving it frequently occurs that by slight changes in the wave frequency either at the transmitter or receiving stations, due to inadvertent approach of the operator's body to parts of the circuits or the switching of the antennae systems in the wind, etc., considerable and annoying changes in the note of the signal are produced. As above stated, and as will be apparent, the system of my invention is free from such objection. Any degree of sensitiveness of reception can easily be obtained by using one or more steps of radio or audio frequency amplification between the antennae system and the telephone receiver.

If desired, and as shown, a high frequency choke coil 30 may be inserted in the input or grid filament circuit of the amplifier 18. The system illustrated in Fig. 2 is substantially the same as that shown in Fig. 1, with the addition of a third winding about the iron core of the transformer 24 and 25. In series with the winding 40 is connected a source of current, such as a battery 31, and rheostat 32 (which, however, may be omitted). The object of this addi-

tional circuit is to saturate the iron core of the transformer 24, 25, in such a direction that the electro-motive force induced in the secondary 25 is uni-directional only, and so
 5 connected to the grid filament electrodes of the audion 21, as to make the grid 23 thereof negative only when a current pulse occurs in the primary winding 24. The
 10 circuits may be supplied with the usual adjustments now well understood in the art and with the usual variance in circuit details now understood to be optional with any particular circuit arrangement.

Many modifications and changes, therefore, may readily occur to those skilled in the art, without departing from the spirit and scope of my invention.

Having set forth, however, the objects and nature of my invention and having
 20 shown and described a circuit arrangement illustrating the method contemplated for the reception of signals in accordance therewith, what I claim as new and useful, and of my own invention, and desire to secure
 25 by Letters Patent is:—

1. The method of receiving radio signals which comprises utilizing the received high frequency current to interrupt itself to thereby produce current impulses of relatively lower frequency.

2. The method of receiving radio signals which comprises utilizing the received high frequency current to interrupt itself to thereby produce current impulses of audio
 35 frequency.

3. The method of producing an audible signal in a radio receiving system which comprises utilizing the received signal current to automatically interrupt itself.

4. The method of producing an audible musical note signal in a radio receiving system, which comprises utilizing the received signal current to automatically interrupt itself.

5. The method of producing an audible signal in a radio receiving system for undamped wave train signals which comprises utilizing the received signal current for automatically interrupting the wave train.

6. The method of producing an audible musical note signal in a radio receiving system, for undamped wave train signals which comprises utilizing the received signal current for automatically interrupting the wave
 55 train.

7. In a receiving system, and in combination with means for receiving an undamped wave train of the transmitted signal, of means automatically operated by the
 60 received wave train for interrupting the wave train to reduce the amplitude of the received undamped wave train.

8. In a receiving system, and in combination with means for receiving an undamped
 65 wave train of the transmitted signal, of

means automatically operated by the received wave train for periodically interrupting the received wave train.

9. In a receiving system, and in combination with means for receiving an undamped wave train of the transmitted signal, of means automatically operated by the received wave train for interrupting the wave train to periodically reduce the amplitude of the received undamped wave train.

10. In a receiving system, and in combination with means for receiving an undamped wave train of the transmitted signal, of means automatically operated by the received wave train for periodically interrupting the received wave train, and means for varying the periodicity of interruption of the wave train.

11. In a receiving system, and in combination with means for receiving an undamped wave train of the transmitted signal, of electrically operating means operated by the received wave train for periodically interrupting the received wave train, and means for varying the periodicity of interruption of the wave train.

12. In a receiving system, and in combination with means for receiving an undamped wave train of the transmitted signal, of means automatically operated by the received wave train for interrupting the wave train to periodically reduce the amplitude of the received undamped wave train, and means for varying the periodicity of fluctuation of amplitude of the wave train.

13. In a receiving system, and in combination with means for receiving an undamped wave train of the transmitted signal, of electrically operating means operated by the received wave train for interrupting the wave train to periodically reduce the amplitude of the received undamped wave train, and means for varying the periodicity of fluctuation of amplitude of the wave train.

14. In a radio frequency receiving system, and in combination with means for receiving an undamped wave train of the transmitted signal, means for rectifying the received radio frequency energy, a secondary circuit, means controlled by the rectified radio frequency energy for inducing a current pulse in said secondary circuit, and means controlled by current pulse in said secondary circuit for rendering said rectifying means inoperative.

15. In a radio frequency receiving system, and in combination with means for receiving an undamped wave train of the transmitted signal, means for rectifying the received radio frequency energy, a secondary circuit, means controlled by the rectified radio frequency energy for inducing a current pulse in said secondary circuit, means controlled by the current pulse in said sec-
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ondary circuit for rendering said rectifying means inoperative, and a signal indicating device controlled by said secondary circuit.

16. In a radio frequency receiving system, and in combination with means for receiving an undamped wave train of the transmitted signal, means for rectifying the received radio frequency energy, a secondary circuit, means controlled by the rectified radio frequency energy for inducing a current pulse in said secondary circuit, means for amplifying the current pulse induced in said secondary circuit, and means controlled by the amplified current pulse in said secondary circuit for rendering said rectifying means inoperative.

17. In a radio frequency receiving system, and in combination with means for receiving an undamped wave train of the transmitted signal, means for rectifying the received radio frequency energy, a secondary circuit, means controlled by the rectified radio frequency energy for inducing a current pulse in said secondary circuit, means for amplifying the current pulse induced in said secondary circuit, and means controlled by the amplified current pulse in said secondary circuit for rendering said rectifying means inoperative, and a signal indicating device controlled by said secondary circuit.

18. In a radio receiving system, and in combination with an antenna system, of an oscillating circuit associated therewith, including two terminals of a thermionic tube, a secondary circuit associated with said oscillating circuit and controlled thereby, means for inducing audio frequency pulsations in said secondary circuit by the energy supplied said oscillating circuit, and means for supplying said audio frequency pulsations to two terminals of said thermionic tube.

19. In a radio receiving system, and in combination with an antenna system, of an evacuated vessel having associated therewith a hot and two cold electrodes, an oscillating circuit including the hot and one cold electrode of said vessel, a secondary circuit associated with said oscillating circuit and controlled thereby, means for inducing audio frequency pulsations in said secondary circuit by the energy supplied said oscillating circuit, and means for supplying said audio frequency pulsations to the other of the cold electrodes of said vessel.

20. In a radio receiving system, and in combination with an antenna system, of an evacuated vessel having associated therewith filament, grid and plate electrodes

of an oscillating circuit connected to the filament and plate electrodes, a secondary circuit associated with said oscillating circuit and controlled thereby, means for inducing audio-frequency pulsations in said secondary circuit by the energy supplied said oscillating circuit, and means for supplying said audio frequency pulsations to said grid electrode.

21. In a radio receiving system, and in combination with an antenna system, of an evacuated vessel having associated therewith filament, grid and plate electrodes, of an oscillating circuit connected to the filament and plate electrodes, a secondary circuit associated with said oscillating circuit and controlled thereby, said secondary circuit comprising the input circuit of an audion amplifier system, means for inducing audio frequency pulsations in said secondary circuit by the energy supplied said oscillating circuit, the output circuit of said audion amplifier system being associated with the grid electrode of said vessel.

22. In a radio receiving system, and in combination with an antenna system, of an evacuated vessel having associated therewith filament, grid and plate electrodes, of an oscillating circuit connected to the filament and plate electrodes, a secondary circuit associated with said oscillating circuit and controlled thereby, said secondary circuit comprising the input circuit of an audion amplifier system, means for inducing audio frequency pulsations in said secondary circuit by the energy supplied said oscillating circuit, the output circuit of said audion amplifier system being associated with the grid electrode of said vessel, and a signal indicating device included in the output circuit of said audion amplifier system.

23. Means for producing a musical note signal at a radio receiving station from a received continuous wave train, comprising a rectifier for the received energy, and means operated by the received energy for rendering said rectifier inoperative.

24. Means for producing a musical note signal at a radio receiving station from a received continuous wave train, comprising a rectifier for the received energy, and means operated by the received energy for rendering said rectifier inoperative, and a signal responsive device included in a circuit associated with said rectifier.

In testimony whereof I have hereunto set my hand on this 26th day of June A. D., 1920.

LEE DE FOREST