May 7, 1935. E. R. HENTSCHEL 2,000,840

SOUND REPRODUCING SYSTEM

Filed May 23, 1930 2 Sheets-Sheet 1

FIG. 1

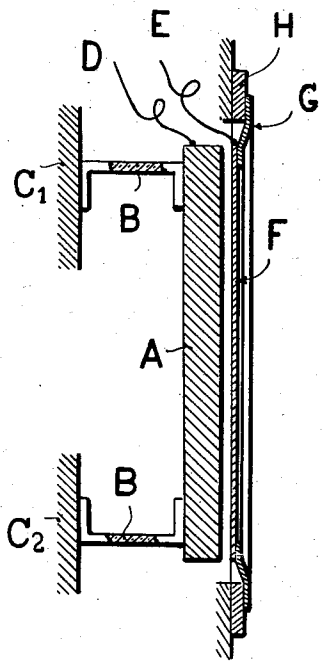


FIG. 2

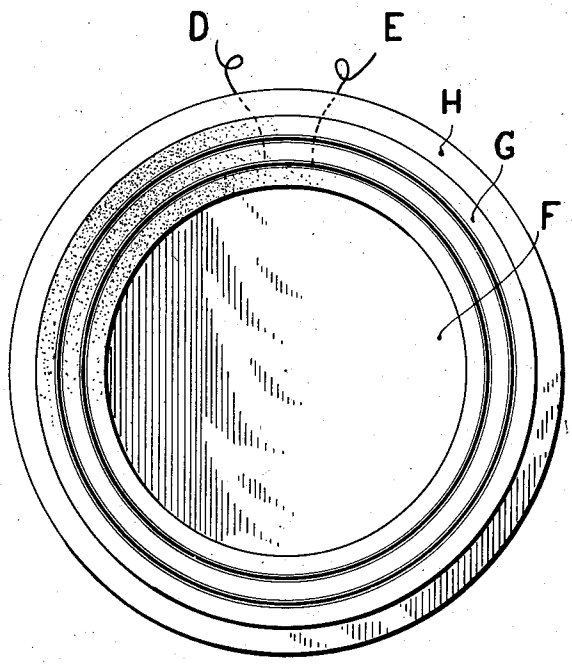
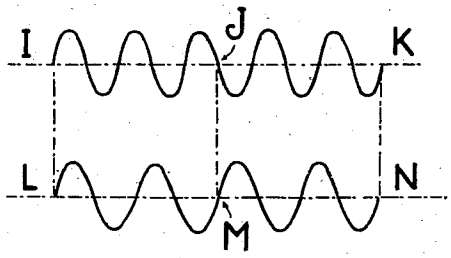


FIG. 3



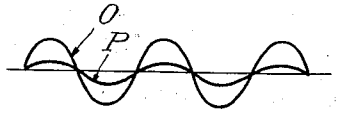


FIG. 5a

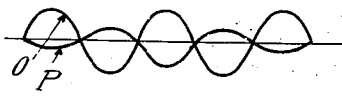


FIG. 5b

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SOUND REPRODUCING SYSTEM

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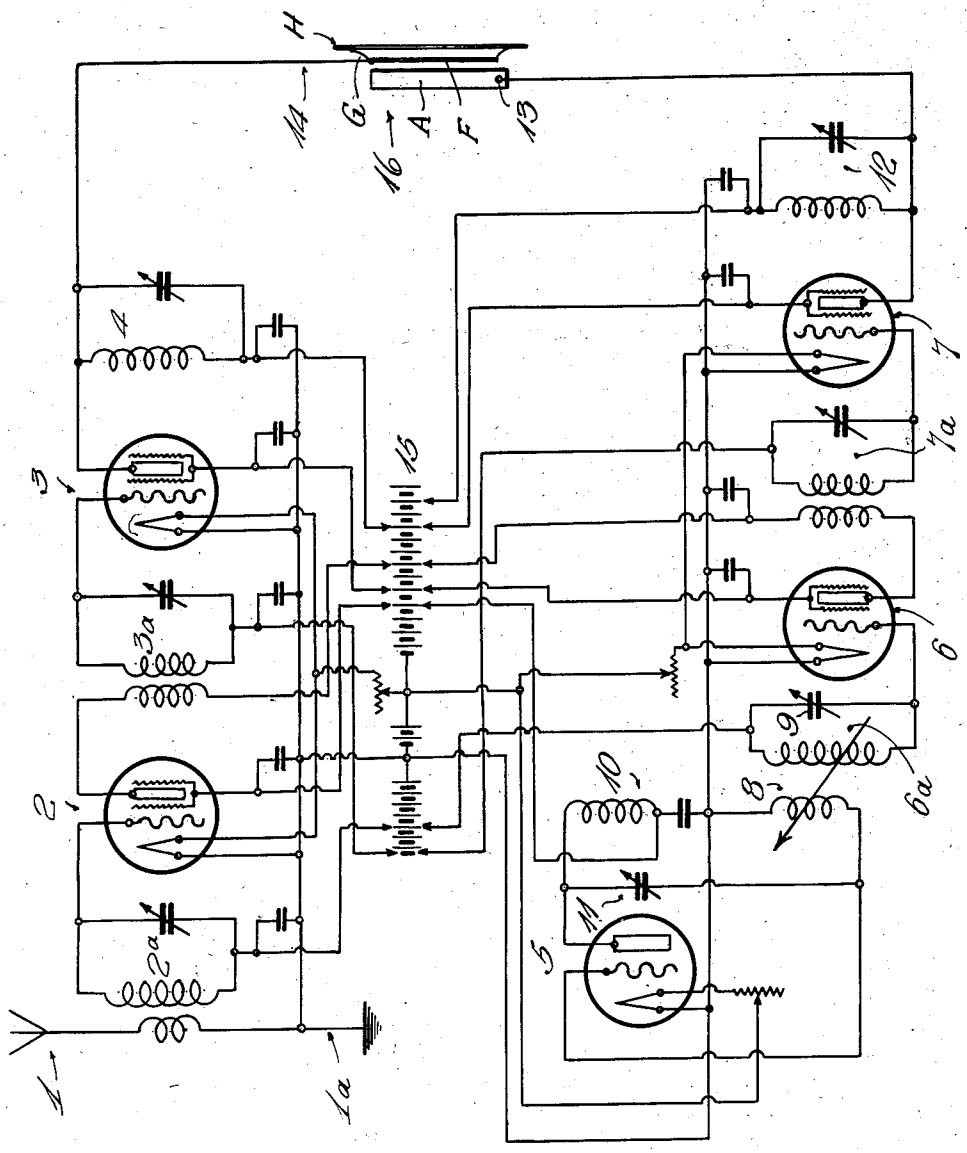

FIG. 4

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2,000,840

SOUND REPRODUCING SYSTEM

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Application May 23, 1930, Serial No. 455,132

3 Claims. (Cl. 250—22)

My invention relates broadly to signal receiving systems and more particularly to a circuit arrangement for a signal reproducing system.

One of the objects of my invention is to provide a circuit arrangement for a sound reproducing apparatus in a signal receiving system.

Another object of my invention is to provide a circuit arrangement for an electrostatically operated sound reproducer in a radio receiving system.

Still another object of my invention is to provide a system for mechanically heterodyning radio frequency currents for the reproduction of signals in a radio receiver.

A further object of my invention is to provide a circuit arrangement for a mechanical detector in a radio receiving system responsive to continuous wave energy.

Other and further objects of my invention reside in the circuit arrangement for a signal receiving system as set forth more fully in the specification hereinafter following by reference to the accompanying drawings, in which:

Figure 1 is a cross-sectional view through one form of the mechanical detector of my invention; Fig. 2 is a front elevation of the detector illustrated in Fig. 1; Fig. 3 shows a set of characteristic curves for explaining the theory of operation of the mechanical detector illustrated in Figs. 1 and 2; Fig. 4 shows a circuit arrangement for the apparatus including the mechanical detector system of my invention; and Figs. 5*a* and 5*b* illustrate a set of characteristic curves describing the theory of operation of my invention.

The circuits of my invention provide means for producing mechanical vibration by the interaction of the incoming signaling energy with a local source of oscillations, the signal response being determined by the construction of the mechanical system in the form of an electrostatically actuated sound reproducer. In the system of my invention I provide an electrostatic sound reproducer including a stationary plate and a movable plate disposed adjacent thereto. Alternating current of different frequencies is applied to the individual plates resulting in alternate retraction and repulsion and vibration of the movable plate at a frequency equal to the difference between the applied frequencies. The tone of the signal reproduction may be determined by the physical properties of the sound reproducer. I have found that in applying the alternating current to the electrodes constituting the electrostatic sound reproducer that it is important to prevent reaction from the operation of the sound reproducing device upon the local source of alternating current at the receiver. The sound reproducing device constitutes a condenser whose capacity varies as the electrostatic speaker operates. This continuous variation in capacity normally tends to affect the constancy of frequency of the oscillator at the receiver. However by interposing a multiplicity of selective circuits between the oscillator and the sound reproducing device, undesired reaction is eliminated.

Referring to Figs. 1 and 2, reference letter A represents a metal plate rigidly fastened to some solid point as at C_1 and C_2 by insulating brackets B. F is a thin light conducting plate mounted for a slight movement toward or away from plate A by means of flexible insulating connections G which in turn are shown fastened to a stationary ring H. D and E are wires which carry charges to and from plates A and F. If these plates are charged from two sources of alternating current, and both are of the same frequency there will be only a steady attraction or repulsion between the two, depending on phase relations. But if the frequency differs there will be alternate attraction and repulsion, and plate F will vibrate. The frequency of this mechanical vibration will be equal to the difference between the two radio frequencies.

The action is illustrated in Fig. 3 which shows two sine electromotive forces. The electromotive force of the upper curve passes through five cycles while that of the lower passes through four. Electromotive force is used instead of current because wires D and E are connected to points of greatest electromotive force for best operation. At the time represented by I and L, both electromotive forces are in phase, so there would be a repulsion between plates A and F. At time J and M the two are 180 degrees out of phase so there would be an attraction. At K and N they are again in phase, so there is a repulsion, and the mechanical cycle is finished.

In Fig. 4 I have shown the circuit arrangement for the receiving apparatus of my invention in which an antenna and ground circuit is illustrated by reference characters 1 and 1*a* to which is coupled a radio frequency amplifier constituted by electron tubes 2 and 3 which are selectively tuned to the incoming signaling frequency by means of circuits 2*a* and 3*a* for delivering energy to the tank circuit 4. An oscillator 5 is provided having coupling coils 8 and 10 in the input and output circuits thereof tuned by means of variable condenser system 11. The oscillator may be variably coupled by coupling

coil 8 which is coupled with inductance 9 in the input circuit of the radio frequency amplifier which includes tubes 6 and 7. The tank circuit 12 is connected in the output circuit of the radio frequency amplifier constituted by tubes 6 and 7 and interstage tuning of the amplifier is obtained by adjustment of circuits 6a and 7a. Screen grid tubes are employed in the several radio frequency amplifier stages for the elimination of undesired capacity coupling. The power supply for the several circuits is obtained from any suitable source which I have represented by reference character 15, common to the circuits of the oscillator 5 and the circuits of both of the radio frequency amplifier systems which operate at different frequencies. By eliminating capacity coupling in the several circuits the separate channels may be operated at different frequencies in close proximity one to the other for impressing upon the speaker system 16 alternating current charges at different frequencies. That is, a connection is taken to the fixed electrode A from tank circuit 12 by means of connection 13. Connection is taken to the flexible diaphragm F by means of lead 14 which connects to tank circuit 4. By adjusting the tank circuits 4 and 12 the voltages are applied to the plates A and F in such relation as to produce the desired tone at the receiver.

For instance, if a 1000 cycle note is desired, the local oscillator frequency should be either 1000 cycles, that is, one kilocycle, higher or lower than that of the incoming signal, as plate F vibrates at a frequency equal to the difference between the two radio frequencies. If both plates are of light construction, and both flexibly suspended, then both plates would vibrate, being attracted towards each other at the time when there is 180° difference in phase between the two electromotive forces, and repelling each other when the two are in phase, 0° phase difference.

The amplifier 6—7 segregates the oscillator 5 from the speaker system for preventing reaction of the varying capacity at the speaker system upon the oscillator, thereby preventing any tendency of the oscillator to change the constant oscillating condition thereof. It will be seen that a detector tube, as ordinarily required and the usual audio frequency amplifier are all eliminated and that the radio frequency potentials which are impressed upon the speaker system beat one against another.

My invention is particularly useful in receiving continuous wave signals for the reception of telegraphic code. If the transmitter however, is modulated by a system which produces variations in the frequency of the carrier wave, then these variations produce corresponding motion in the plate F. For instance, if the transmitter frequency were 1,001,000 cycles and the local oscillator frequency, circuits 5, 8, 10, 11, were 1,000,000, we would have a 1,000 cycle note. If now the transmitter changes to 1,002,000, there would be a 2,000 cycle note produced, and if it had changed to 1,000,050, plate F would be vibrating 50 times per second.

The system of my invention is adaptable to broadcast reception by adjusting the frequency of oscillator 5 to the frequency of the transmitter. Under these conditions an electromotive force is produced on fixed plate A through lead 13 from tank circuit 12 represented by curve O in Fig. 5a. The incoming signaling energy produces a charge on the movable plate F designated by curve P and as the electromotive force between the two plates varies the repelling force varies and motion is produced. A condition of zero phase relation of the incoming energy with respect to the locally produced energy at the same frequency has been illustrated in curve 5a. In curve 5b a 180° phase relationship is assumed and there is a constant attraction between the plates A and F and the variations in amplitude of the received signal will cause a variation in the attraction between the plates.

In operation the electrostatic device has many advantages over electromagnetic forms of sound reproducers, among which may be mentioned improved tone quality, cheapness in manufacture and production, and simplified assembly of the parts constituting the loud speaker construction.

While I have described one of the preferred embodiments of my invention, I desire that it be understood that modifications may be made and that no limitations upon my invention are intended other than are imposed by the scope of the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is as follows:

1. In a sound reproducing system an electrostatic sound reproducer comprising a pair of electrodes disposed in parallel relation and movable in respect to each other, a source of received radio frequency oscillations, a local source of radio frequency oscillations, a radio frequency amplifier having its input connected to said source of received oscillations, a tuned circuit comprising an inductance and a capacity connected in the output circuit of said amplifier, a second radio frequency amplifier having its input connected to said local source of radio frequency oscillations, a second independent tuned circuit comprising inductance and capacity connected in the output circuit of said second amplifier, and means including connections between the electrodes of said sound reproducer and suitable points in each of said tuned circuits for applying to each of said electrodes individually an oscillating potential of the particular frequency produced in the tuned circuit to which it is connected, whereby a beat frequency electrostatic reaction between said electrodes is obtained.

2. In a sound reproducing system, an electrostatic sound reproducer comprising a fixed electrode and a flexible electrode disposed in parallel relation, a source of received radio frequency oscillations, a local source of radio frequency oscillations, a radio frequency amplifier having its input connected to said source of received oscillations, a tuned circuit comprising inductance and capacity connected in the output circuit of said amplifier, a second radio frequency amplifier having its input connected to said local source of radio frequency oscillations, a second independent tuned circuit comprising inductance and capacity connected in the output circuit of said second amplifier, and means including connections between the electrodes of said sound reproducer and suitable points in each of said tuned circuit for applying to each of said electrodes individually an oscillating potential of the particular frequency produced in the tuned circuit to which it is connected, whereby a beat frequency electrostatic reaction between said electrodes is obtained.

3. In a device of the class described, an electrostatic sound reproducer including a pair of electrodes disposed in parallel relation to one another,

a signal receiving channel responsive to modulated high frequency energy, amplifying means in said signal receiving channel, a local source of oscillations, amplifying means connected thereto and means including independent connections between each of said amplifying means and one of said electrodes for impressing the signaling energy and the energy from the local source of oscillations independently upon said electrodes whereby an electrostatic beat frequency interaction between said electrodes becomes effective for the reproduction of sound.

ERNEST R. HENTSCHEL.