Feb. 8, 1949. H. F. OLSON 2,461,344

SIGNAL TRANSMISSION AND RECEIVING APPARATUS

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Fig. 1.

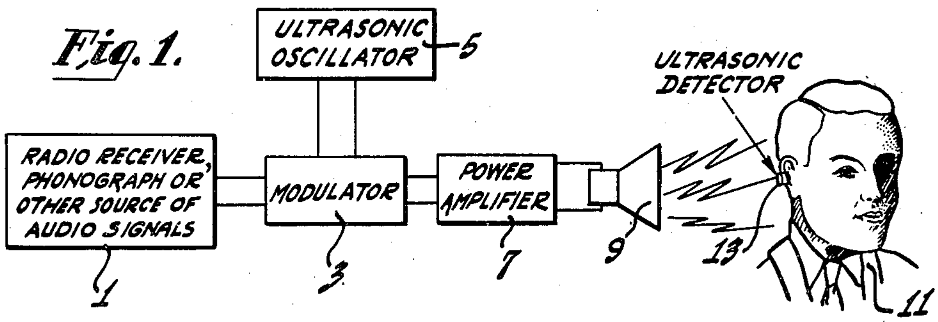

Fig. 2.

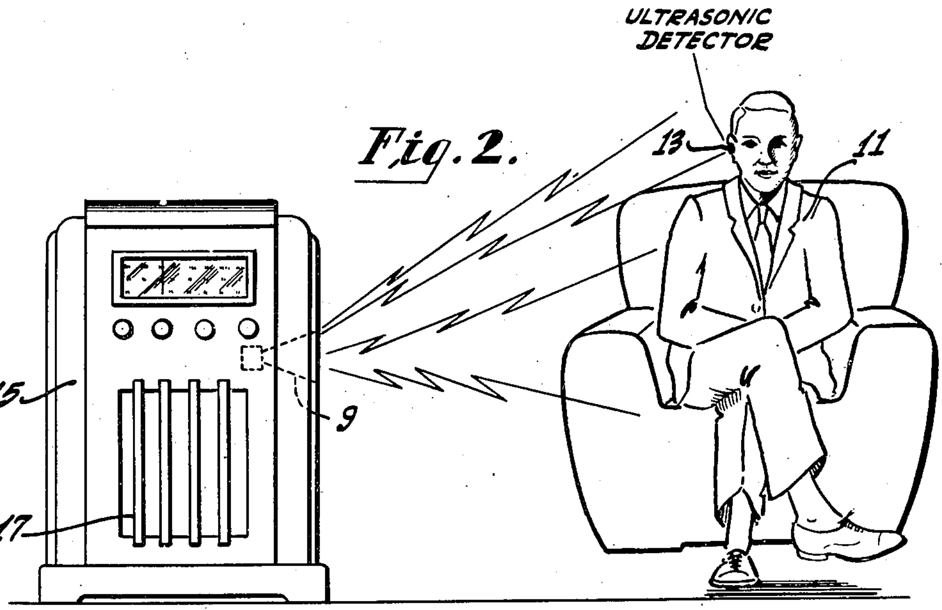

Fig. 3.

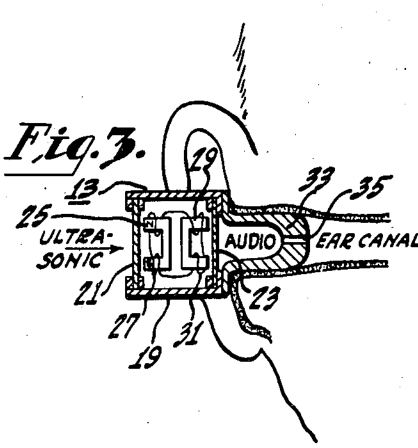

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Fig. 4.

Fig. 5.

Fig. 6.

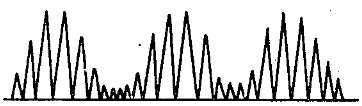

Fig. 7.

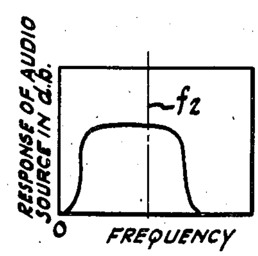

Fig. 8.

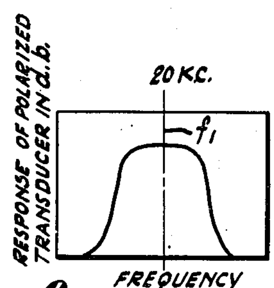

Fig. 9.

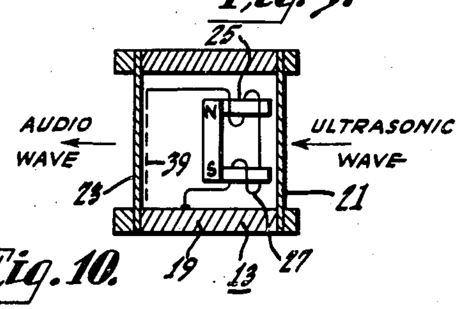

Fig. 10.

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2,461,344

UNITED STATES PATENT OFFICE

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SIGNAL TRANSMISSION AND RECEIVING APPARATUS

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Application January 29, 1945, Serial No. 575,008

6 Claims. (Cl. 179—1)

This invention relates to signal transmission and receiving apparatus, and more particularly to an ultrasonic transmission system which is particularly useful as a personal sound system.

There are numerous instances where, as between two or more individuals, one may wish to listen to a radio program, or to a series of announcements from a public address system, or to some other device or system which delivers sound, while another person may not wish to listen thereto. For example, in the home, one individual may wish to enjoy a radio program while another one, occupied by some task requiring mental concentration, finds himself greatly disturbed thereby. In a number of other instances too, a similar situation may be found where a personalized system may be of great advantage.

The primary object of my present invention, therefore, is to provide an improved sound transmitting system which can be used only by those wishing to receive and listen to the matter being transmitted.

More particularly, it is an object of my present invention to provide an improved, personal, intelligence transmitting system which will not disturb those who do not wish to listen to the matter being transmitted.

Another object of my present invention is to provide an improved receiver device, in a system of the type set forth above, for the purpose of detecting modulated acoustical waves by purely mechanical and acoustical means.

Still another object of my present invention is to provide an improved receiver device as aforesaid which can be worn inconspicuously in the ear of a listener.

It is also an object of my present invention to provide an improved transmission system and receiving device as above set forth which will be quite inexpensive, easy to install and operate, and highly efficient in use even over substantial distances.

In accordance with my present invention, the ultrasonic transmission system comprises a source of audio frequency signals the output of which is fed to a modulator. The modulator is also supplied with a signal of ultrasonic frequency from a suitable oscillator. The output of the modulator may be connected to an ultrasonic loudspeaker through a suitable power amplifier, whereby the loudspeaker will produce or generate modulated ultrasonic, compressional waves in the air or other ambient. These modulated, ultrasonic waves may be detected by means of a detector forming part of my present invention.

The detector is preferably of the insert type to be worn in the ear of one who desires to listen to the subject matter which is transmitted and comprises a polarized electroacoustic transducer in which the wave shape of the voltage output corresponds to the wave shape of the acoustic input. The output of the polarized transducer is coupled to an unpolarized electroacoustic transducer in which the acoustic output is proportional to the square of the voltage input. The combination of the polarized and unpolarized transducers makes it possible to detect a modulated acoustic wave and, since it is worn in the ear of the listener, this device provides a personal receiver by means of which radio or other programs will not disturb those who do not wish to listen to such programs. In the interest of conserving power and reducing the interfering effects of reflections, the ultrasonic loudspeaker is preferably made directional.

The novel features that I consider characteristic of my invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and method of operation, as well as additional objects and advantages thereof, will best be understood from the following description when read in connection with the accompanying drawings in which

Figure 1 is a wiring diagram showing a transmitting and receiving system in accordance with my present invention,

Figure 2 is a similar view but showing a radio receiver as the source of audio frequency signals, the cabinet housing the radio receiver also including the ultrasonic loudspeaker as well as the other requisite elements of the transmitting device,

Figure 3 is a central, sectional view through one form of a receiver according to my present invention, the receiver being shown mounted in the ear,

Figure 4 is a curve representing the unmodulated, ultrasonic carrier wave,

Figure 5 is a curve showing the ultrasonic carrier wave modulated by an audio frequency wave,

Figure 6 is a curve showing the detected wave and representing the force on the diaphragm of the receiver which generates the final, acoustical wave into the ear,

Figure 7 is a curve representing the audio output of the receiver,

Figure 8 is a curve showing the response of the audio system,

Figure 9 is a curve showing the response of the ultrasonic system, and

Figure 10 is a central, sectional view through modified form of receiver device constructed accordance with my present invention.

Referring more particularly to the drawings in hich similar reference characters designate cor- sponding parts throughout, there is shown, in ig. 1, a source of audio frequency signals 1 hich may be a radio receiver, a phonograph, a icrophone, or the like and the output of which fed to a suitable modulator 3. To the modula- or 3, there is also supplied a signal from an scillator 5 which operates at an ultrasonic fre- uency (for example 20 or 25 kc. per second), s represented by the curve of Fig. 4. Thus, the utput of the modulator 3 is an ultrasonic signal nodulated by an audio frequency signal, as shown y the curve of Fig. 5. This output may be con- ected to a power amplifier 7, the output of which, n turn, is connected to an ultrasonic loudspeaker . The loudspeaker 9 therefore produces or gen- rates in the surrounding air or other ambient a ignal represented by the curve of Fig. 5. This ignal is received by a listener 11 who wears in is ear an ultrasonic detector 13 to be described n greater detail hereinafter.

The audio source 1, the modulator 3, the ultrasonic oscillator 5, the power amplifier 7 and the loudspeaker 9 may all be embodied in a radio receiver cabinet 15 of any suitable type or design, and the loudspeaker 9 may be either the loudspeaker usually found behind the grille 17 of the cabinet 15, if it is of a suitable type, or it may be an additional loudspeaker added to the cabinet. If desired, more than one oscilaltor 5 may be connected to the modulator 3, each operating at a different frequency, and the modulated outputs of the modulator 3 may be supplied to different loudspeakers, each of which may or may not point in a different direction from the others. The use of additional oscillators operating at different ultrasonic frequencies makes the system more versatile in that several programs may be transmitted simultaneously and received by different individuals without interference from the others. Preferably, the loudspeaker or loudspeakers 9, as the case may be, are made directional to conserve power and reduce interfering effects of reflections and from other transmitted waves. The listener 11 will be seated in the line of transmission of the waves corresponding to the particular program of interest to him.

One form of combined receiver and detector 13 according to my present invention is shown in Fig. 3 and comprises a casing 19 normally open at both ends which are closed off by vibratory diaphragms 21 and 23 of magnetic material. The diaphragm 21 has associated therewith a polarized generator comprising a U-shaped magnet 25 which forms the core of a winding 27. The diaphragm 23 has associated therewith an unpolarized motor comprising a U-shaped member of magnetic material which forms the core of a winding 31. The winding 27 is connected to the winding 31 so that the output of the generator 25, 27 is applied to the input of the motor 29, 31. The casing 19 is also preferably supplied with a tubular member 33 having an opening 35, the member 33 being insertable into the ear canal of the ear of the listener.

If an ultrasonic sound of pressure p' and frequency f_1, which may be 20 kc. per second, for example (see Fig. 9), is impressed on the diaphragm 25, the voltage output of the coil 27 will be

$$e=K_1p'\sin 2\pi f_1t \qquad (1)$$

where
p' is the sound pressure,
f_1 is the frequency, and
K_1 is a constant of the system.

If a voltage e of frequency f_1 is impressed upon the unpolarized transducer 29, 31, 23, the sound pressure output will be

$$p''=K_2e^2\sin^2(2\pi f_1t) \qquad (2)$$

Equations 1 and 2 show that this system is a square law system and therefore will detect modulated ultrasonic waves.

Let an ultrasonic wave of frequency f_1 (see Fig. 9) be modulated by a wave of frequency f_2 (see Fig. 8). The equation for the modulated ultrasonic wave will be

$$p'=K_3p_1\sin 2\pi f_1t+K_4p_1p_2\cos 2\pi(f_1+f_2)+K_4p_1p_2\cos 2\pi(f_1-f_2) \qquad (3)$$

where
p_1 is the sound pressure amplitude of the carrier wave,
p_2 is the sound pressure amplitude of the modulating audio frequency wave,
f_1 is the frequency of the carrier wave,
f_2 is the frequency of the modulating audio frequency wave, and
K_3 and K_4 are constants.

Substituting Equation 3 in Equation 1, the voltage output of the polarized transducer will be

$$e=K_1[K_3p_1\sin 2\pi f_1t+K_4p_1p_2\cos 2\pi(f_1+f_2)+K_4p_1p_2\cos 2\pi(f_1-f_2)] \qquad (4)$$

If this voltage is applied to the unpolarized transducer 29, 31, 23, then, substituting Equation 4 in Equation 2,

$$p_2=K_1^2[K_2K_3p_1\sin 2\pi f_1t+K_4p_1p_2\cos 2\pi(f_1+f_2)+K_4p_1p_2\cos 2\pi(f_1-f_2)]^2 \qquad (5)$$

This is the force on the audio diaphragm 23.

Simplifying Equation 5 and retaining the audio term because the audio diaphragm 23 can respond only to audio frequencies,

$$p_2=K_5\sin 2\pi f_2$$

where K_5 is a constant. From the foregoing analysis, it is apparent that the receiver 13 will act as a detector of modulated, ultrasonic waves.

In Figure 9, I have shown a somewhat different form of receiver 13 in which the polarized, electromagnetic motor 25, 27 is retained, but in place of the unpolarized electromagnetic generator 29, 31, I employ an unpolarized, condenser transducer comprising the conductive diaphragm 23 and an associated conductive grid electrode 39 which is spaced slightly from the diaphragm 23 and forms a condenser therewith. The output of the generator winding 27 is applied to the condenser generator 23, 29 as shown in Fig. 10. This system can also act as a detector of modulated ultrasonic waves because the unpolarized condenser transducer is a square law device.

In place of the unpolarized magnetic motor of Fig. 3 or the unpolarized condenser motor of Fig. 10, an unpolarized dynamic motor may be employed. Also, in place of the polarized magnetic generator of Fig. 3, there may be employed a polarized condenser, dynamic, or magnetostriction generator or, if desired, a crystal piezoelectric or a carbon generator may be employed. Various other similar changes will, no doubt, readily suggest themselves to those skilled in the art.

A system such as that described above can be used to advantage not only in the home, but in many quasi-public places, such as clubs, lounges, hotel lobbies, railroad cars, dining rooms, restaurants, etc., where those desiring to listen to a program need merely insert a small, inconspicuous receiver 13 in the ear, while those who do not wish to listen to the program will be free of annoyance. A system of this sort may also find usefulness in mines or in factories over areas or in locations where a great deal of noise or other extraneous sound exists, or where it is desired to communicate between two individuals in secrecy to the exclusion of others. An especially important use for my present invention is for prompting actors in a play. With a transmission and receiving system as above described, the prompter can talk with complete freedom to the actor who has one of the receivers 13 in his ear without knowledge on the part of the audience. Many other uses will, no doubt, readily suggest themselves, as will also other variations in the particular forms of the invention described herein. I therefore desire that my invention shall not be limited except insofar as is made necessary by the prior art and by the spirit of the appended claims.

I claim as my invention:

1. A system for producing and transmitting in an unconfined medium ultrasonic compressional waves modulated at audio frequencies and for detecting the audio frequency modulation components of said waves without the use of a power source, said system comprising, in combination, a source of audio frequency signals, an ultrasonic oscillator, means associated with said source for modulating the output of said oscillator in accordance with said audio frequency signals to provide a modulated ultrasonic signal, a signal translating device adapted to generate compressional waves and arranged to generate said waves in the unconfined ambient, means for applying said modulated ultrasonic signal to said translating device whereby said device will generate in the unconfined ambient ultrasonic compressional waves modulated at said audio frequencies, and a receiver exposed to said ambient in spaced relation to said translating device for receiving said modulated compressional waves, said receiver being adapted to be powered solely by the modulated compressional waves received thereby and to detect said audio frequency modulation components when so powered, said receiver being further adapted to be worn in the ear of a listener and comprising a generator and a motor, said generator including a vibratory member exposed to the ambient, and said motor including a vibratory member arranged to face the ear canal when said receiver is worn in the ear, the output of said generator being connected to the input of said motor.

2. A system for producing and transmitting in an unconfined medium ultrasonic compressional waves modulated at audio frequencies and for detecting the audio frequency modulation components of said waves without the use of a power source, said system comprising, in combination, a source of audio frequency signals, an ultrasonic oscillator, means associated with said source for modulating the output of said oscillator in accordance with said audio frequency signals to provide a modulated ultrasonic signal, a signal translating device adapted to generate compressional waves and arranged to generate said waves in the unconfined ambient, means for applying said modulated ultrasonic signal to said translating device whereby said device will generate in the unconfined ambient ultrasonic compressional waves modulated at said audio frequencies, and a receiver exposed to said ambient in spaced relation to said translating device for receiving said modulated compressional waves, said receiver being adapted to be powered solely by the modulated compressional waves received thereby and to detect said audio frequency modulation components when so powered, said receiver comprising (1) a polarized, electro-acoustic transducer including a vibratory member exposed to the ambient and responsive to said modulated ultrasonic compressional wave, the voltage output of said transducer corresponding to the wave shape of the acoustic input to said vibratory member, and (2) an unpolarized, electro-mechanical converter including a vibratory member adapted to generate acoustical waves, the output of said transducer being connected to the input of said converter, and said converter vibratory member having an acoustic output which is proportional to the square of the voltage input thereto from said transducer.

3. A device for receiving ultrasonic waves modulated at audio frequencies which comprises a first vibratory member adapted to be exposed to and actuated by said waves, a polarized voltage generator associated with said vibratory member and responsive thereto to generate a voltage corresponding to the wave shape of the acoustic input to said member, an unpolarized motor connected to the output of said generator, and a second vibratory member associated with said motor, said second vibratory member being responsive to said motor to generate acoustical waves proportional to the square of the voltage input to said motor from said generator and corresponding to said audio frequencies.

4. A device according to claim 3 characterized in that said first named vibratory member, said generator, said motor and said second vibratory member are all combined in a unitary structure.

5. A device according to claim 3 characterized in that said first named vibratory member, said generator, said motor and said second vibratory member are all combined in a unitary structure, and characterized further in that said structure is adapted to fit in the ear of a listener.

6. A device according to claim 3 characterized in that said first named vibratory member, said generator, said motor and said second vibratory member are all combined in a unitary structure, and characterized further in that said structure includes a tubular member adapted to fit into the ear canal of the ear of a listener, said tubular member being coupled to said second vibratory member.

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